FRONTIERS Summer school 2021

VIRTUAL VISIT TO PIERRE AUGER OBSERVATORY

Monday 12th of July at 18 CET

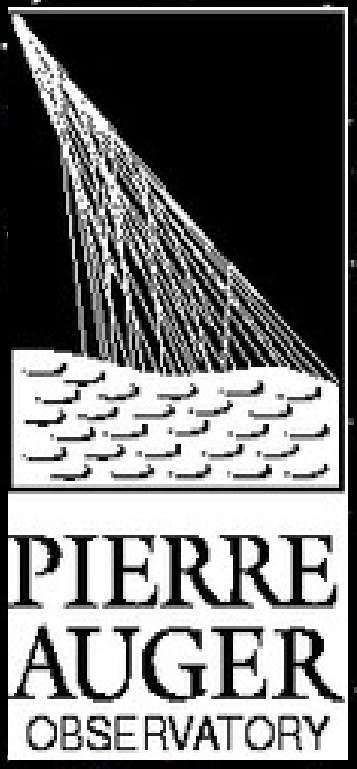
BROADCASTING LIVE

facebook.com/frontierseu

Co-funded by the Erasmus+ Programme of the European Union

Welcome to Pierre Auger Observatory

A Multidisciplinary Proyect of Basic and Applied Science



Nicolás Leal
Ricardo Sato
Mariano del Río
Marcos Cerdá
Javier Salinas
Gualberto Ávila
Beatriz García

What are Cosmic Rays?

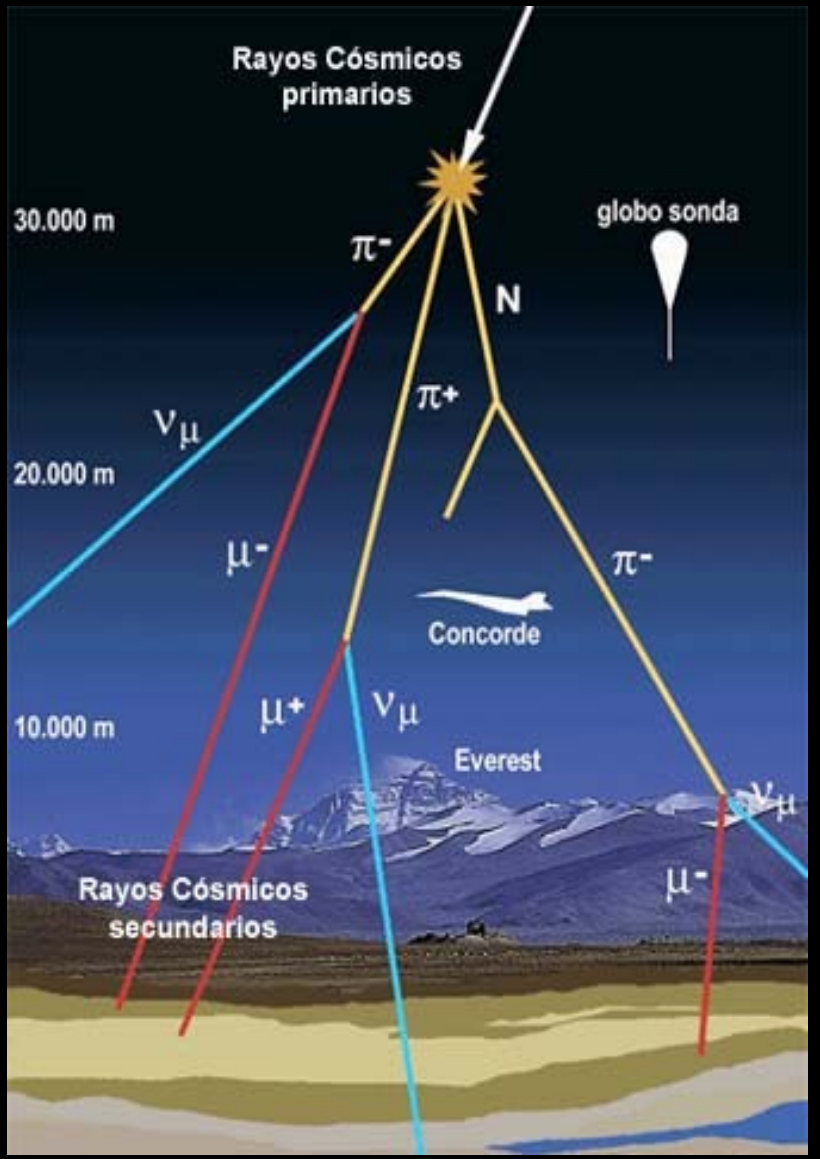
* Nuclei with composition similar to those of solar system + gammas, neutrinos
* The products of the interaction and decay reach the Earth's surface
* Low energies: Sun (10 => 100 MeV)

* The rate at the surface 1/ seg cm^2

* High energy (up 10 EeV)
* Galactic sources (supernovas)
* Extra-galactic sources

The rate at the surface 1/ century km^2

What the Pierre Auger Observatory studies

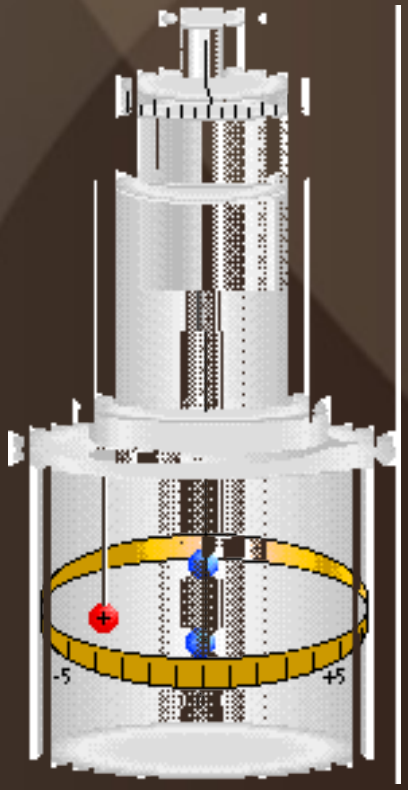


Brief History I

1785 - COULOMB

Analyzed the discharge rate of electroscopes.

He did not find a satisfactory explanation .



1909 - WULF

It was assumed that the "penetrating radiation" may come from Earth.

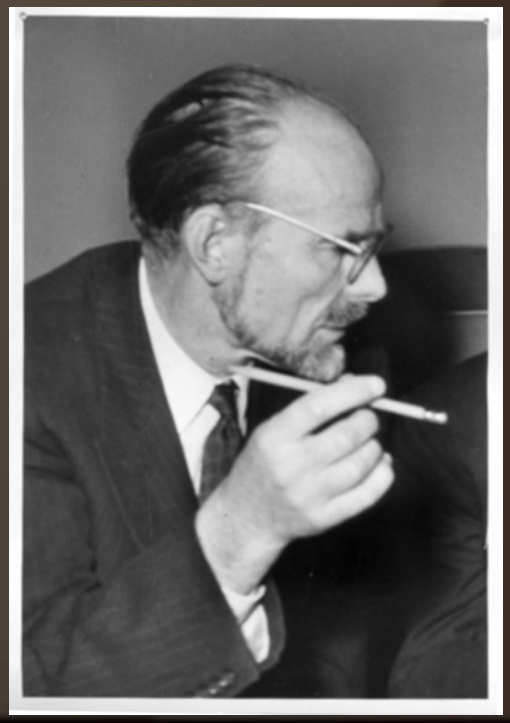
Wulf analyzed if it is modified with the height: measures in the Eiffel Tower, without conclusive results.

Brief History III

1938 - Pierre Auger

- Geiger detectors installed in the Swiss Alps.

Discovered the "cosmic showers" cascades of secondary subatomic particles caused by the collision of high-energy primary particles with air molecules.



Showers of energies ten million times higher than any known before.

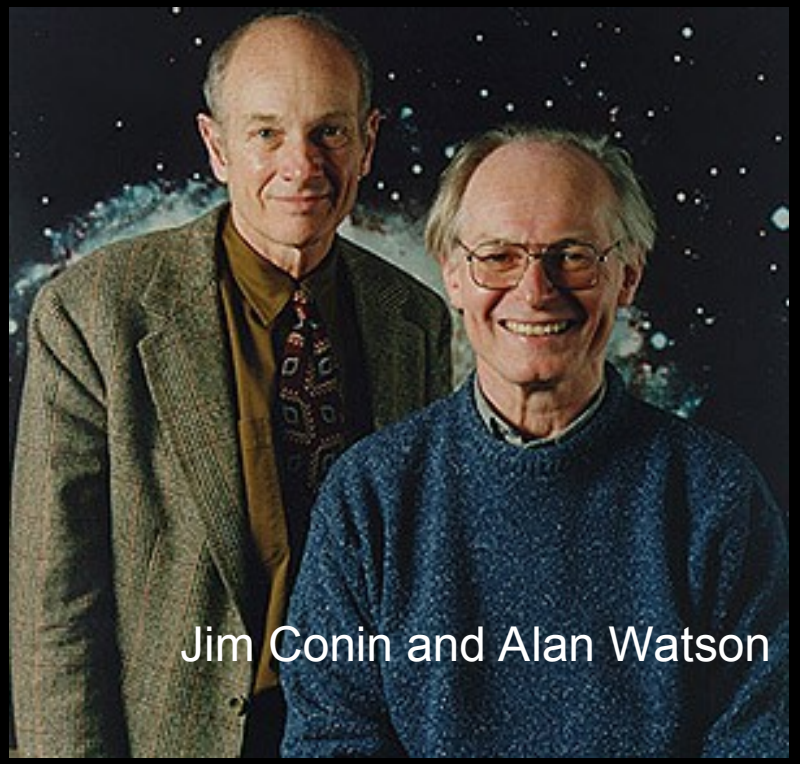
1938: It was concluded that they were mostly protons (their flux depends on the magnetic field)

Time Line for Pierre Auger Observatory I

1991 - Concept - Giant Array Observatory, Dublin-ICRC

1995 - Feb-July Workshop for final design

1995 - November: International Collaboration creation UNESCO, París

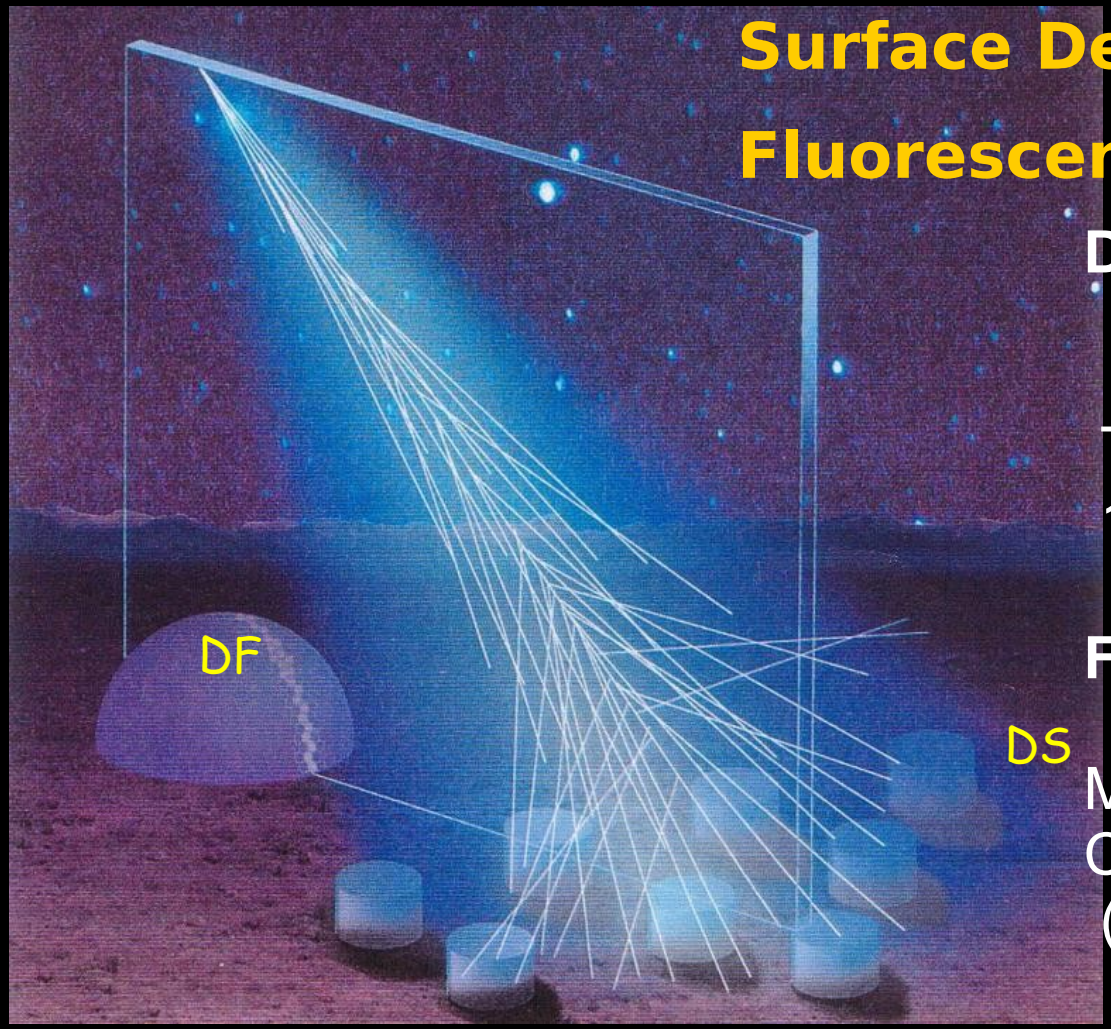


Jim Conin and Alan Watson

Alberto Etchegoyen
Raúl Colomb

Pierre Auger Observatory

What are the UHE-CR, where they came from, whay they arrive with such high energy?



Surface Detectors-DS (1660)

Fluorescence Detectors-FD (24+3)

DS:

Covered area: 3000 km2.
Distance-detectors: 1,5 km.
Type of detection: Cherenkov,
12000 I-H_2O,3 PMT

FD-Telescopes:

~ 30 km for UEH showers of 10^{20} eV.
Mirrros: 3.6 m x 3,6 m, FOV 30º x 30º
Cameras: 440 PMTs each telescope (6 by building)

Auger Collaboration

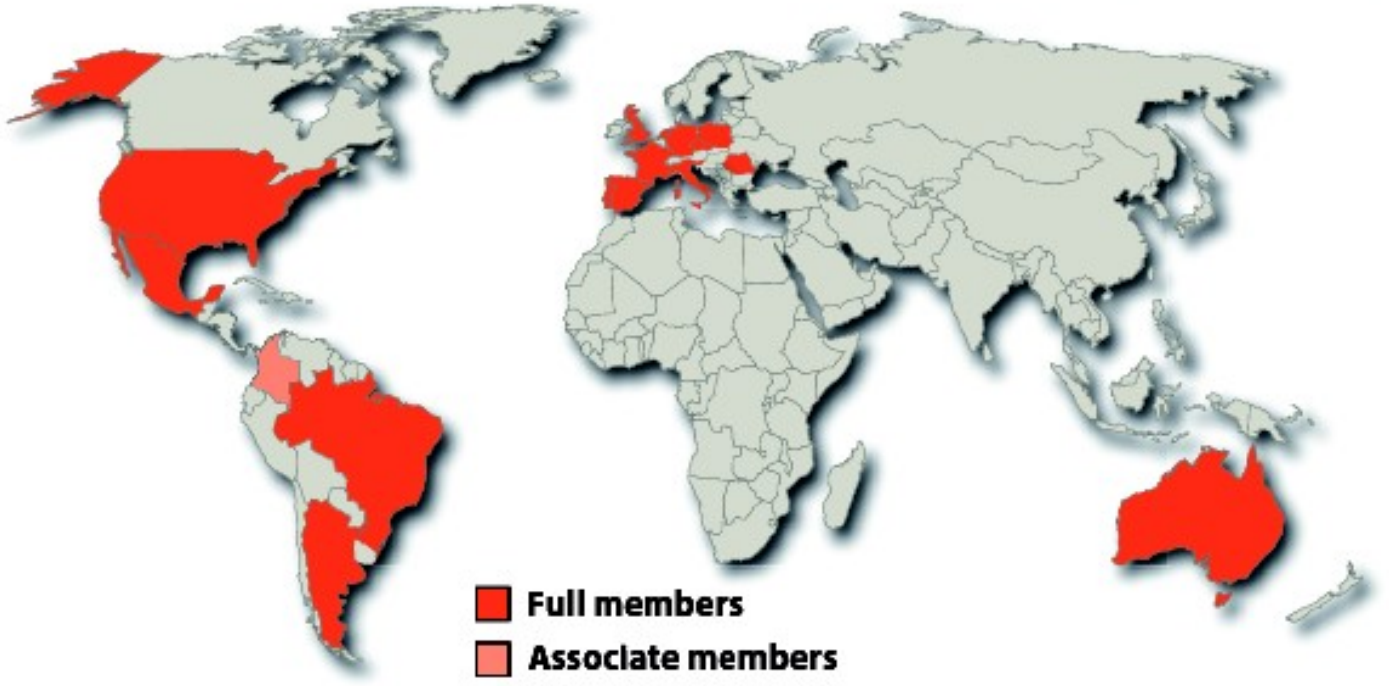
PIERRE AUGER OBSERVATORY

425 Collaborators; 92 Institutions, 17 Countries:

Argentina
Australia
Belgium *new*
Brazil
Colombia
Czech Republic
France
Germany
Italy
Mexico
Netherlands
Poland
Portugal
Romania
Slovenia
Spain
UK
USA

CB report by
L. Nellen / L. Perrone

102 PhD students
(290 completed
until 7/17,
thereof 24 in 2016)
+many master St.



Time Line for Pierre Auger Observatory II

1999- March,15 – Memorandum of Understanding- Mendoza

1999 – March,18. Inauguration of Malargüe site

2001 – May, 23. First Fluorescence event

2001 – July, 21. First Surface event

2001 – December, 9. First Hybrid event

2005 – August. First meeting on PAO results

2007 – November. First important paper

2008 – Full installation inauguration

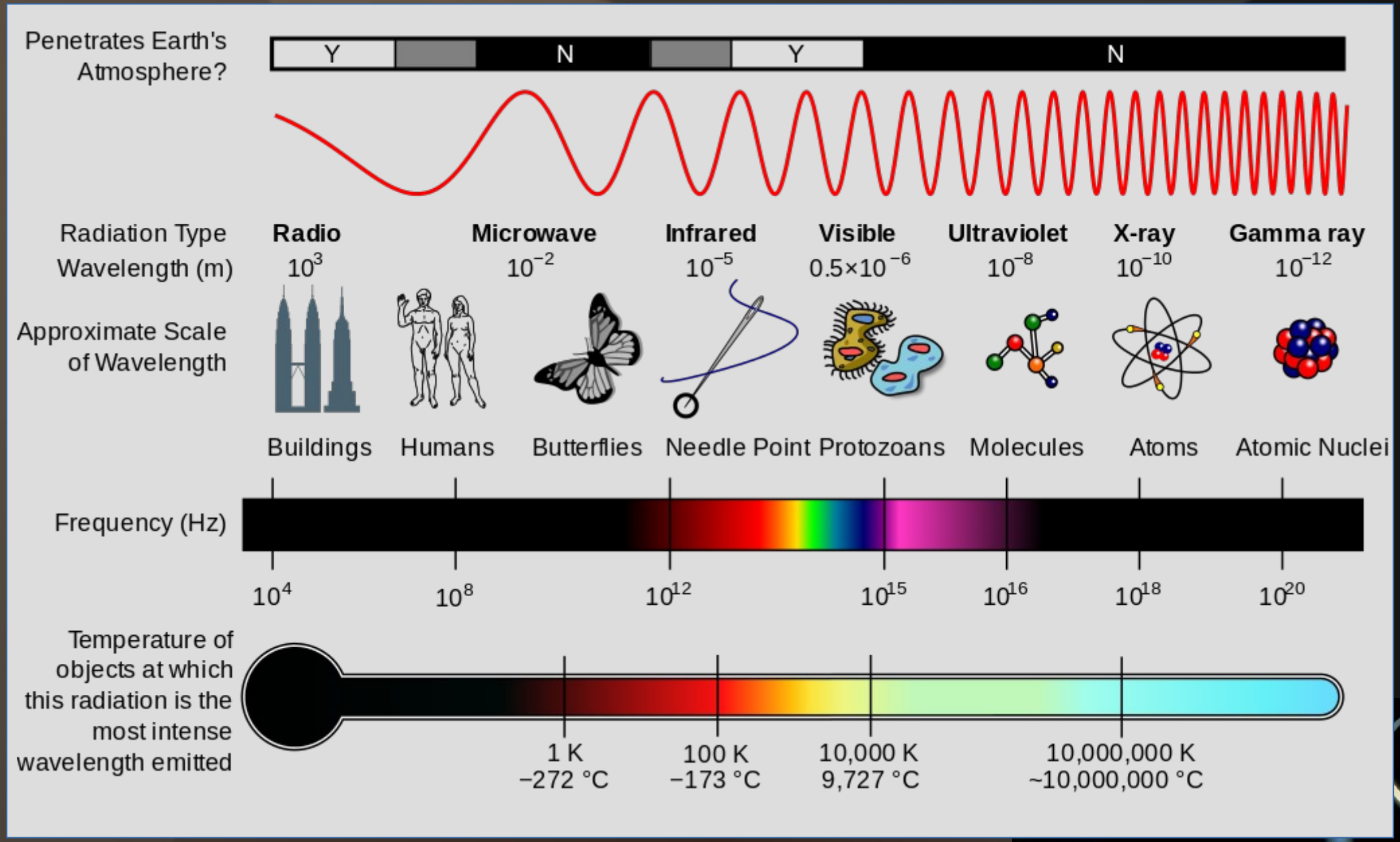
Astronomy is the study of celestial objects.

It is the study of almost all the properties of the Universe from stars, planets and comets to the largest cosmological structures.
and phenomena across the entire electromagnetic spectrum and more.

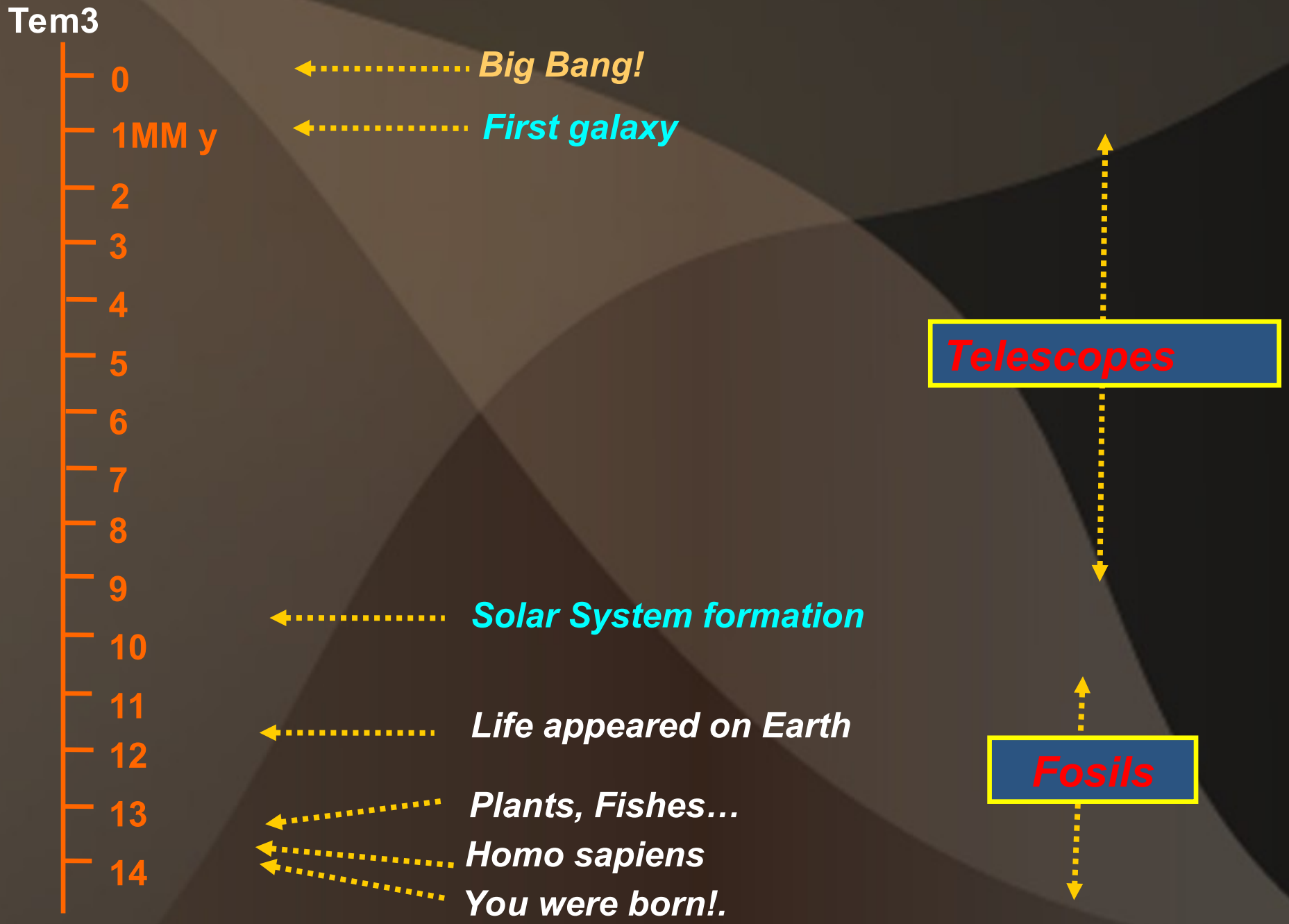
It is the study of everything that existed, exists and will exist

Our knowledge about Cosmos photons...

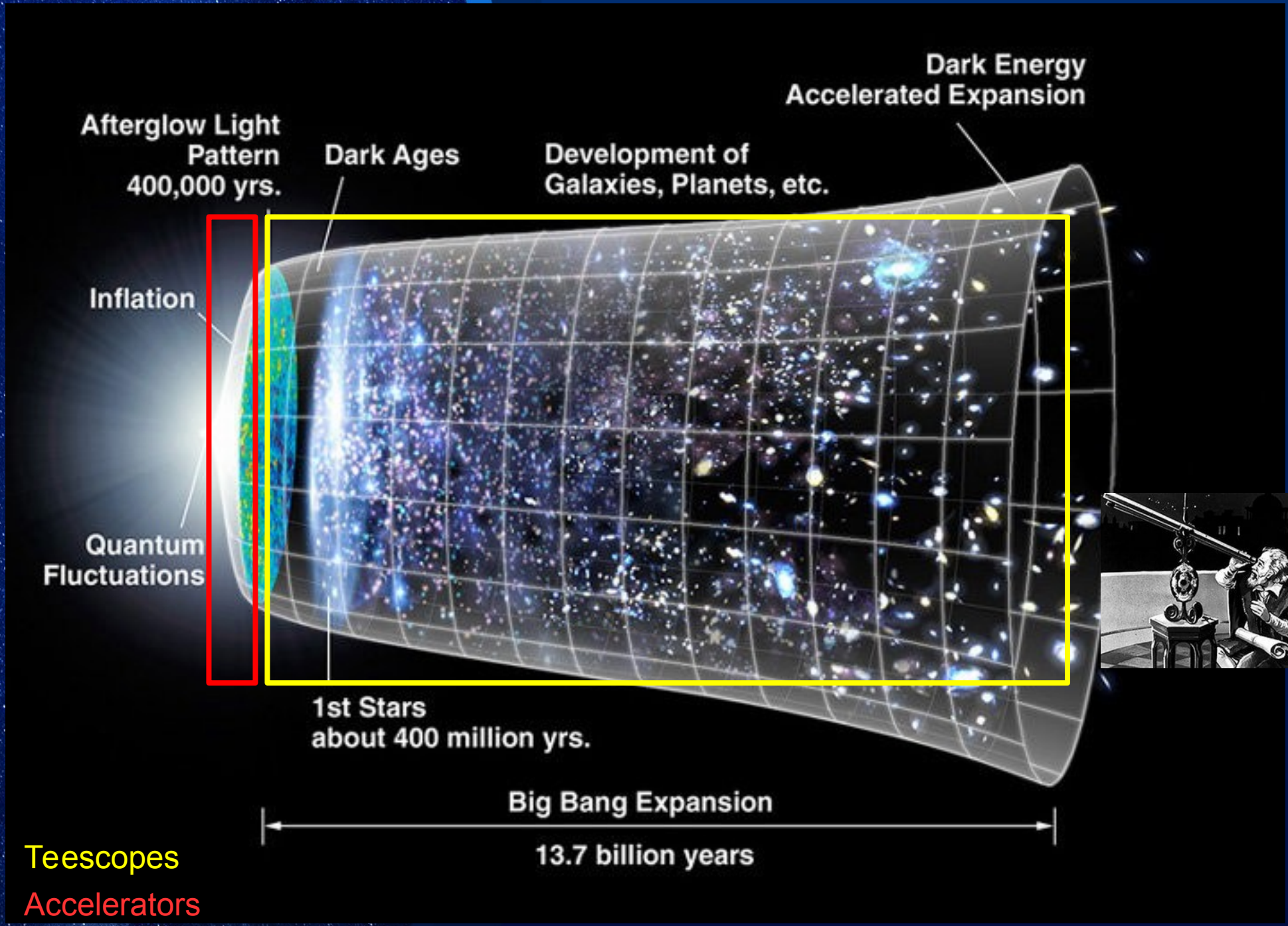
Electromagnetic Spectrum



Brief History of Universe and Life



History of the universe



Teescopes

Accelerators

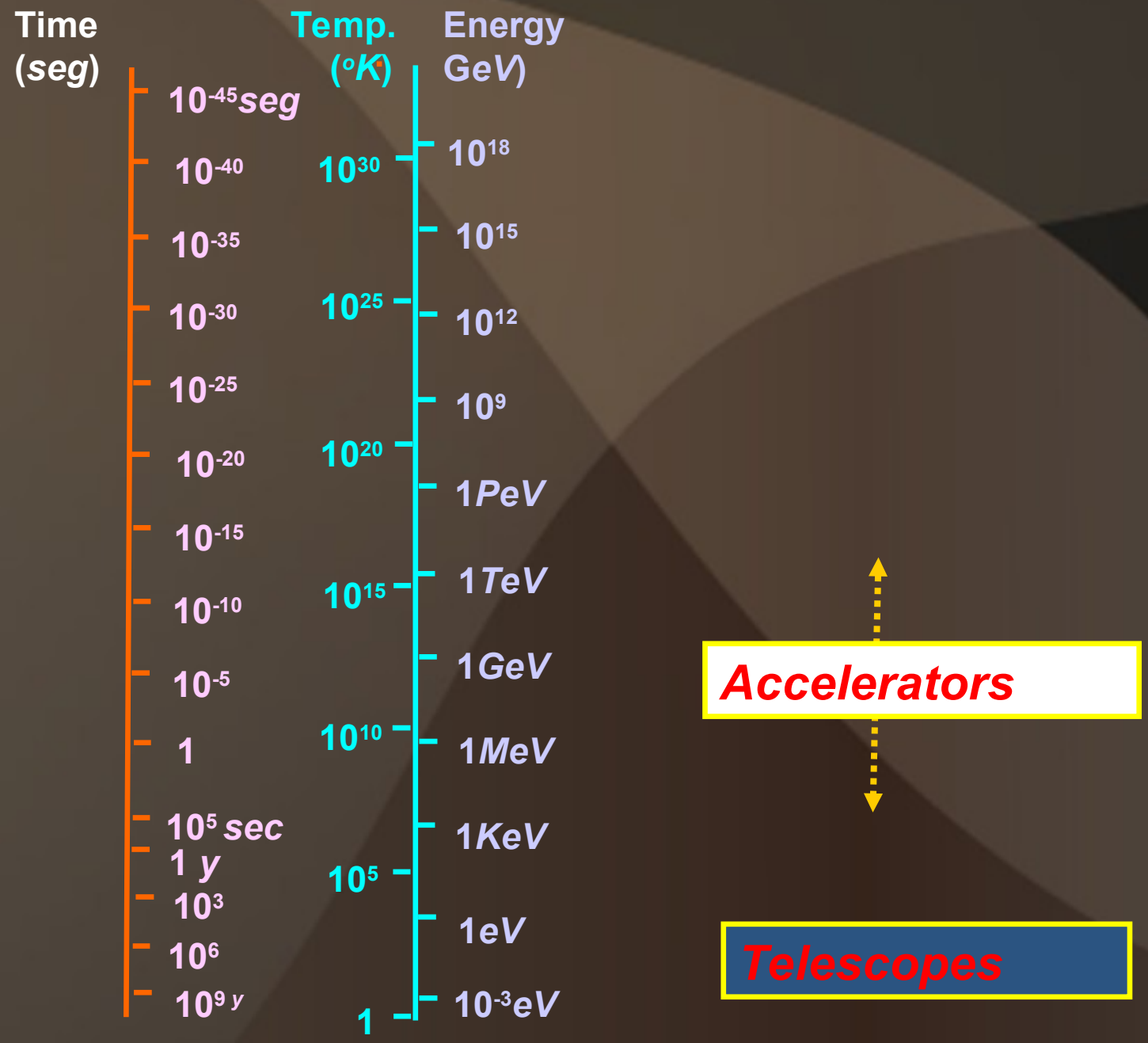
Our knowledge abut Cosmos particles...

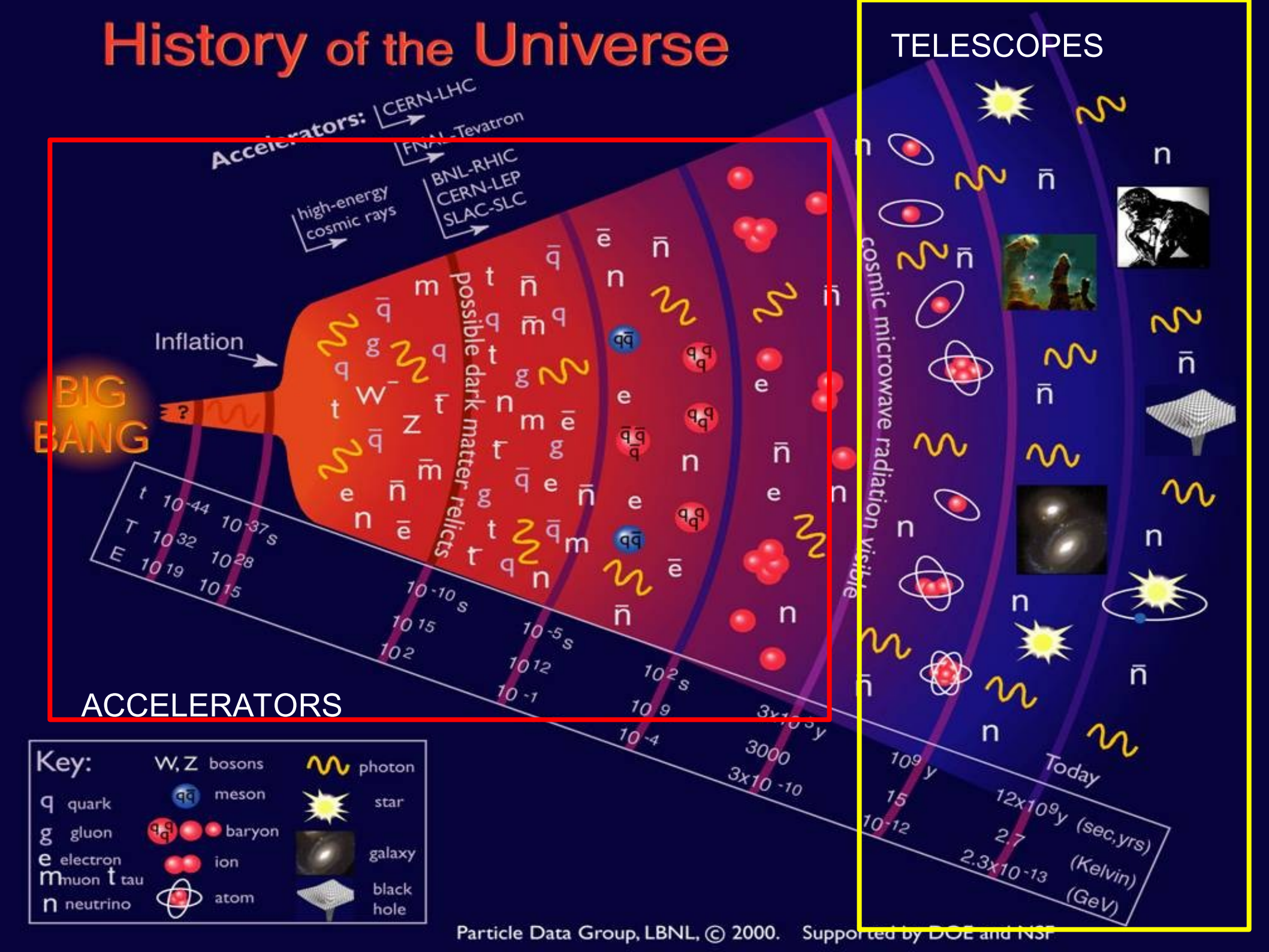
The particles interact each other.

High-energy particles arrive from the cosmos and interact with the atmosphere and water.

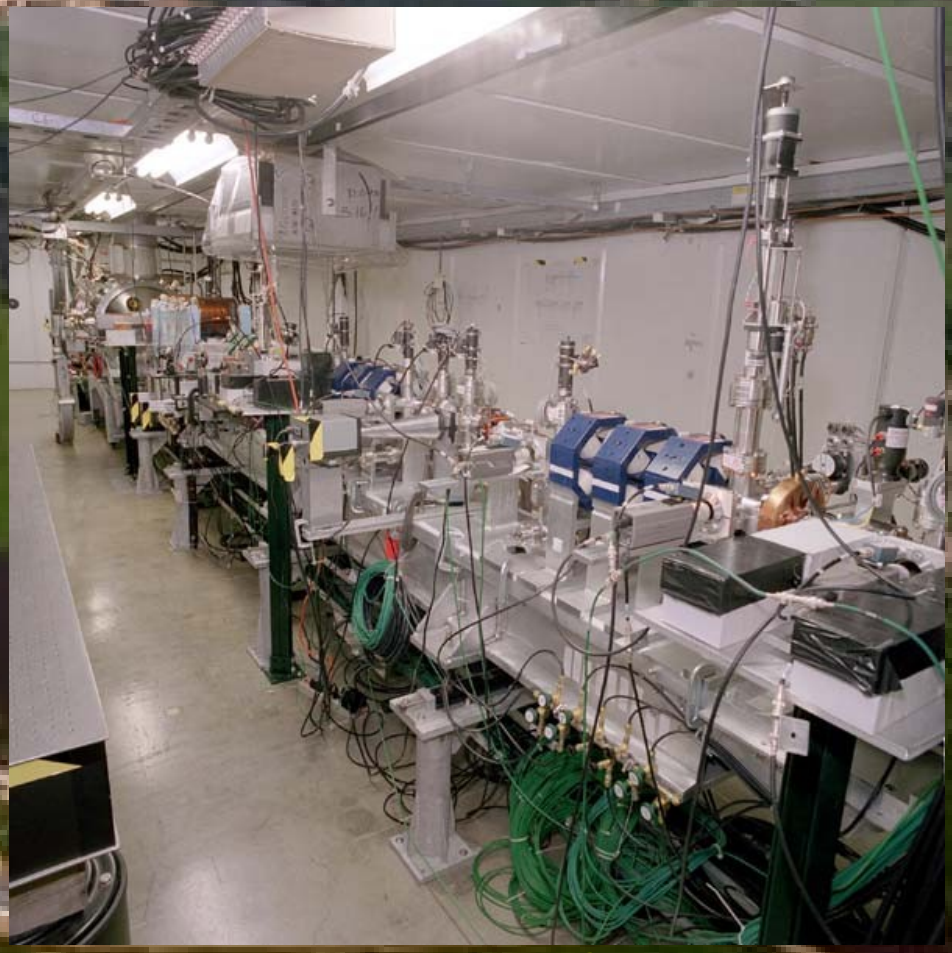
The interaction of particles with matter produces light.

Tools to explore the Primitive Universe




History of the Universe
TELESCOPES
Accelerators:
CERN-LHC
FNAL-Tevatron
BNL-RHIC
CERN-LEP
SLAC-SLC
high-energy cosmic rays
Inflation
BIG BANG
possible dark matter relicts
cosmic microwave radiation visible
ACCELERATORS
t 10-44 10-37 s
T 1032 1028
E 1019 1015
10-10 s
10 15
10 2
10-5 s
10 12
10 -1
102 s
10 9
10 -4
3000
3x10 -10
109 y
15
10-12
12x109y (sec,yrs)
2.7 (Kelvin)
2.3x10 -13 (GeV)
Today
Key:
q quark
g gluon
e electron
m muon t tau
n neutrino
W, Z bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole
Particle Data Group, LBNL, © 2000.
Supported by DOE and NSF

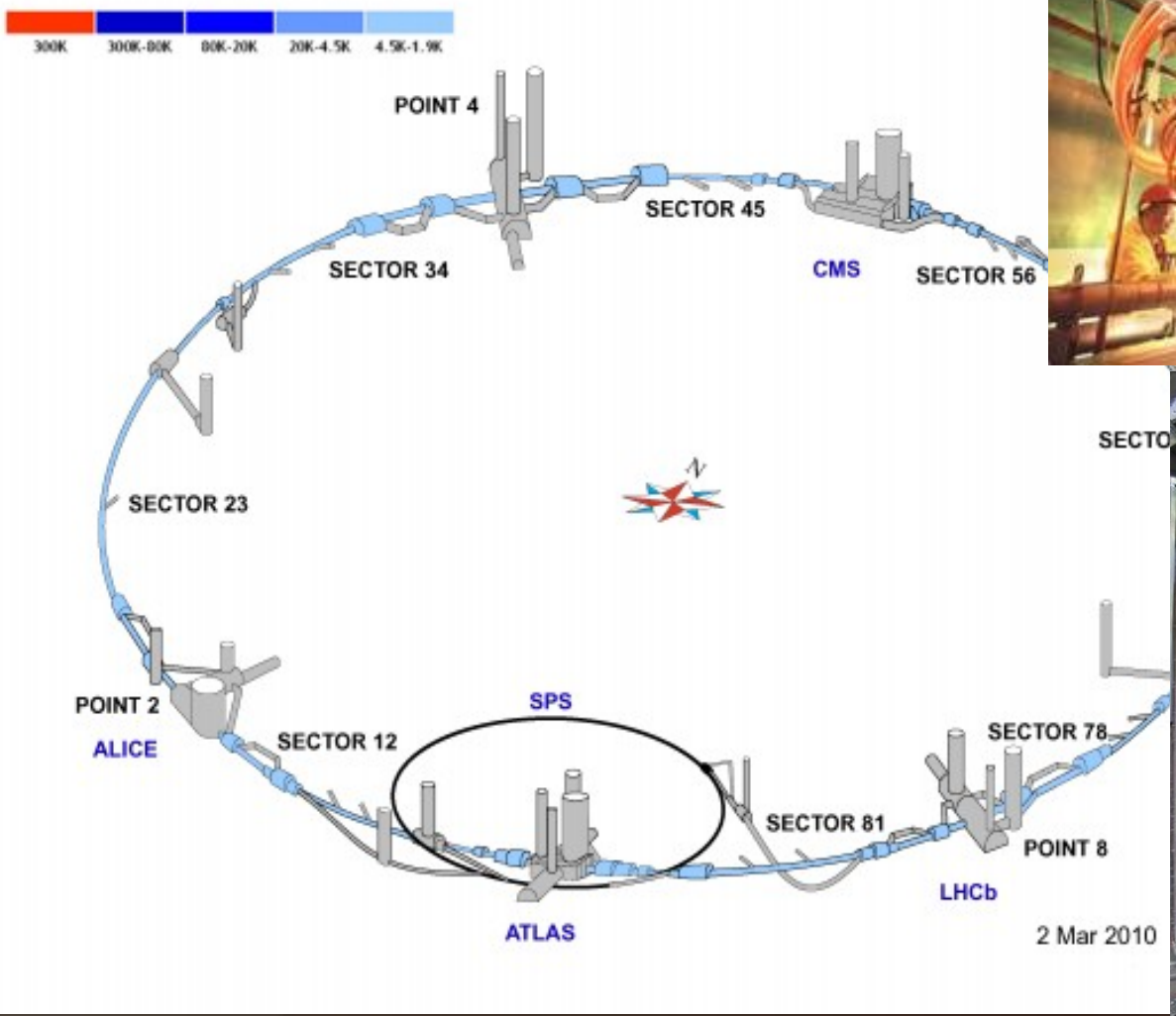
Fermi Lab, near Chicago

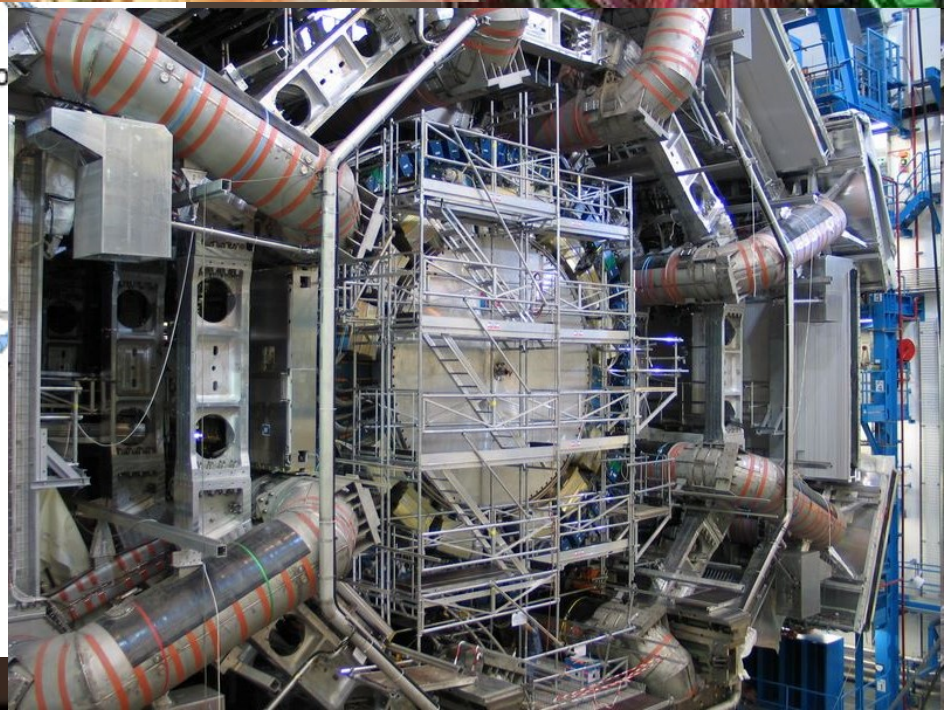


2 TeV


CERN in Ginebra
Circunference de 27km
14 TeV

Large Hadronic Collider

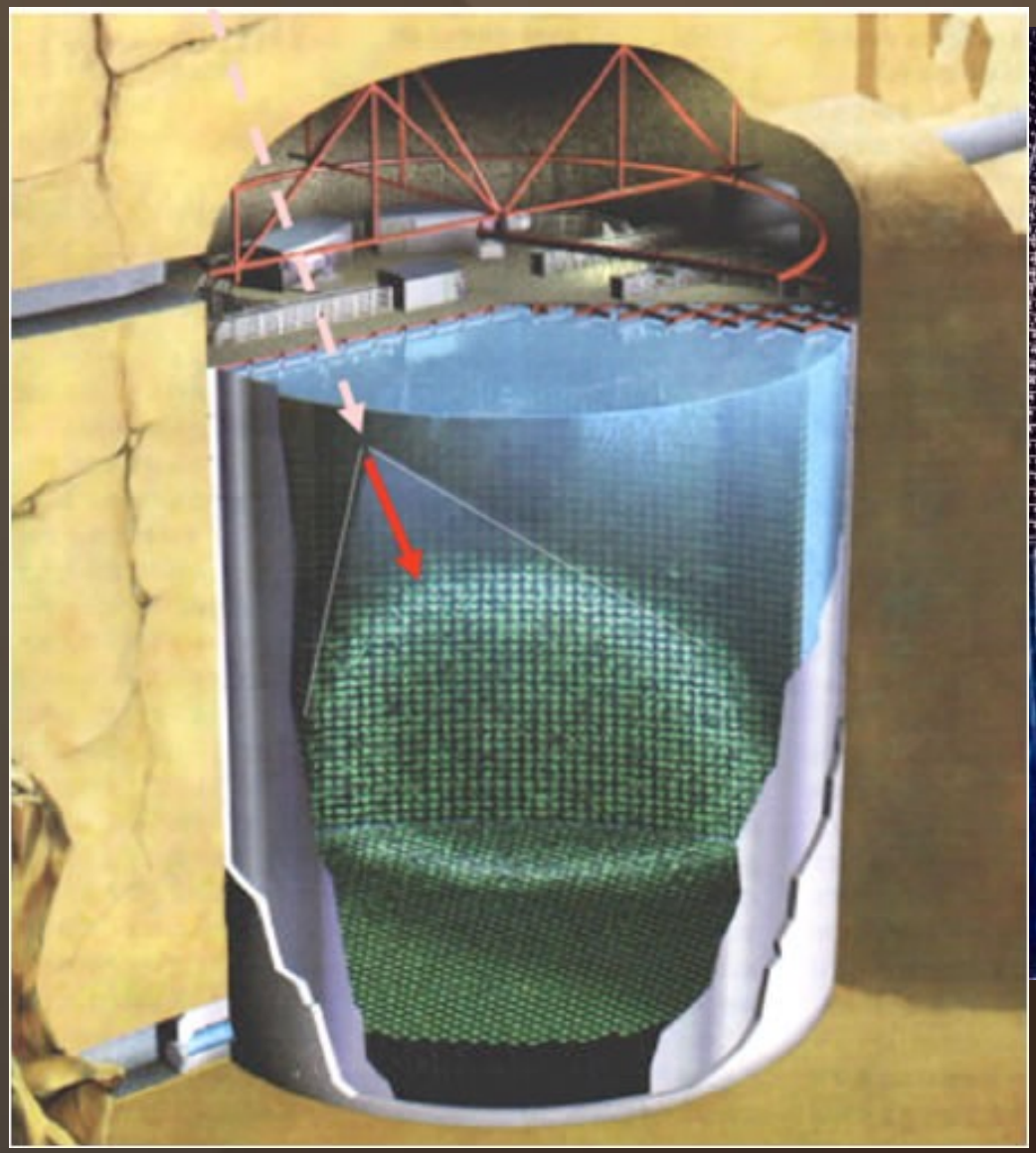


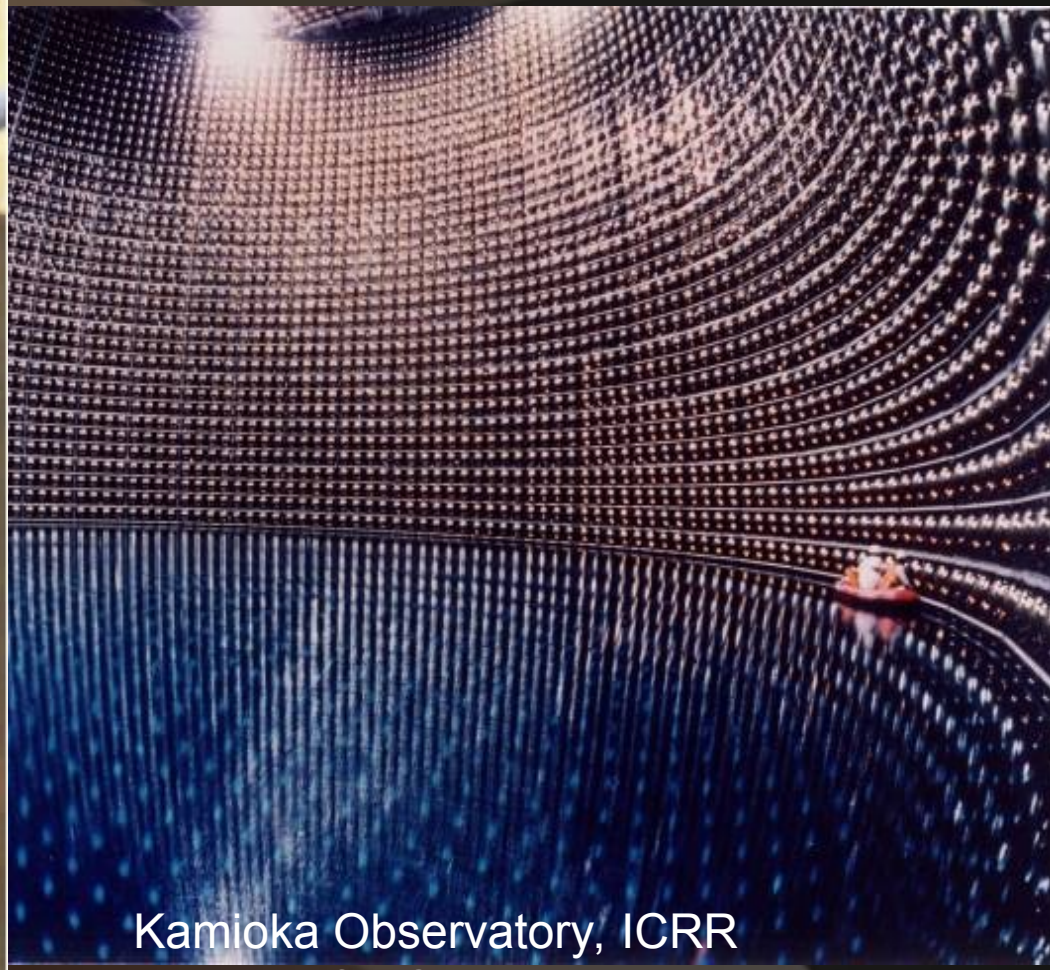


SuperkamiokaNDe

Construction 1996 -Reconstruction 2006

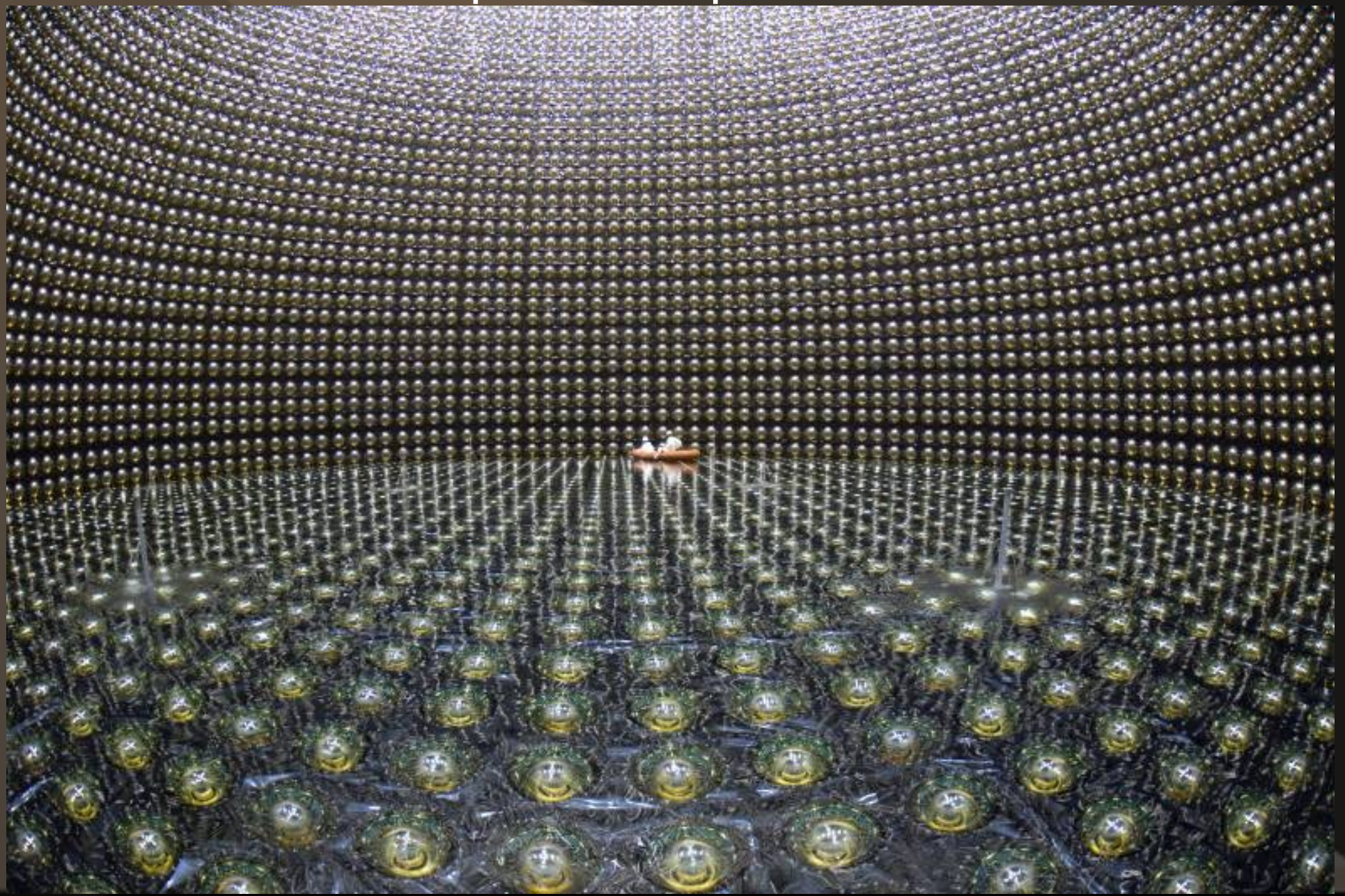
1.000 m under sea level, Mozum mine

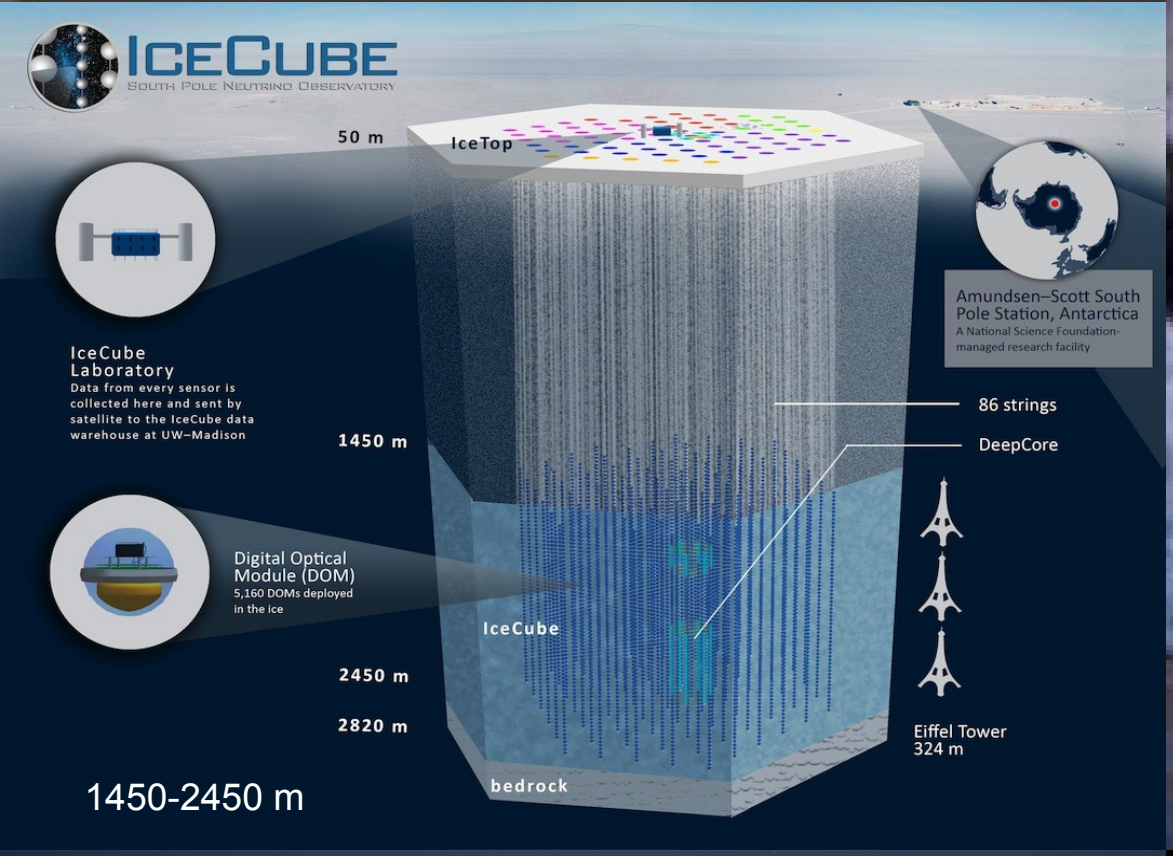


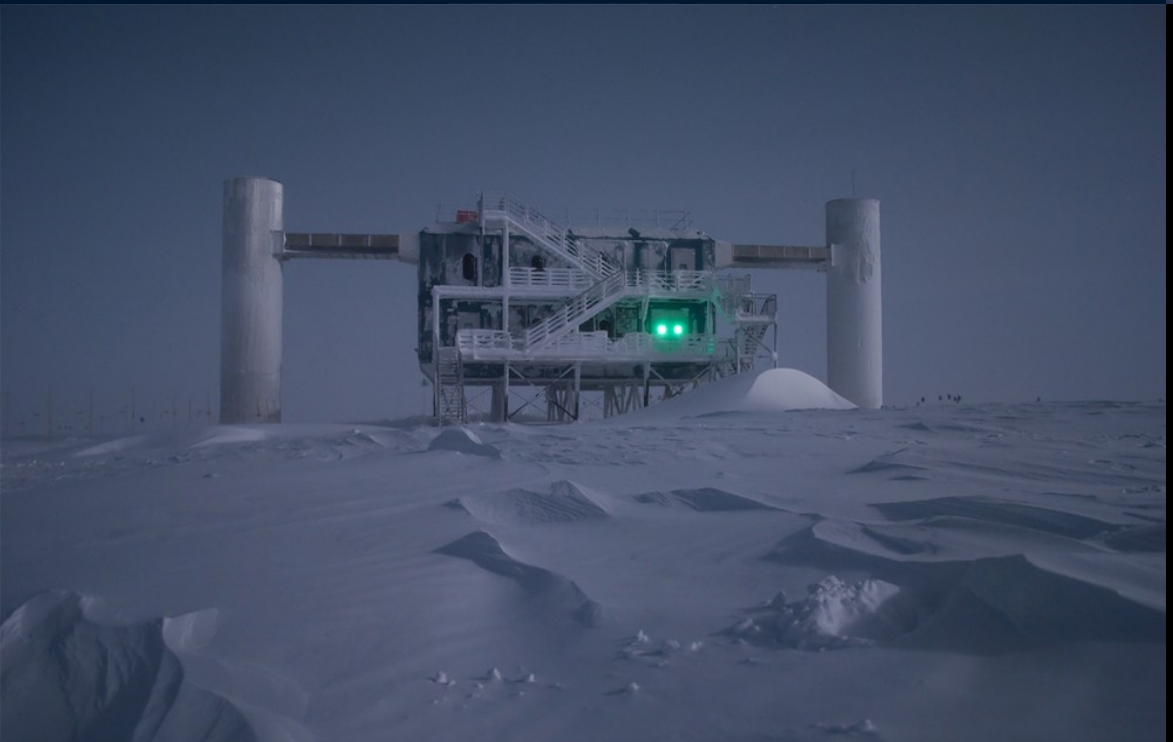


Kamioka Observatory, ICRR
(Institute for Cosmic Ray Research),
The University of Tokyo

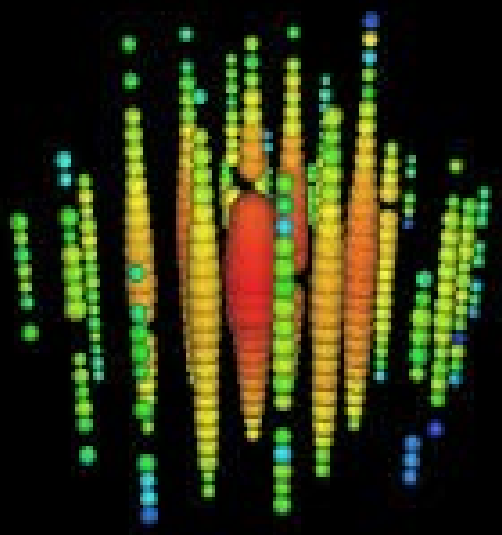
50,000 tons of pure water surrounded by about 11,000 photomultiplier tubes.







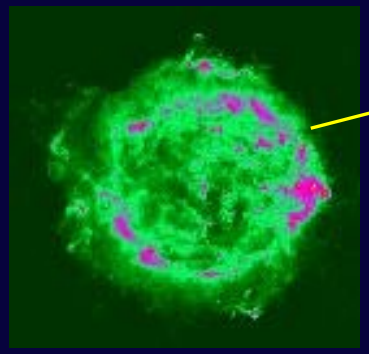
2012-first detection 2 HE-neutrinos

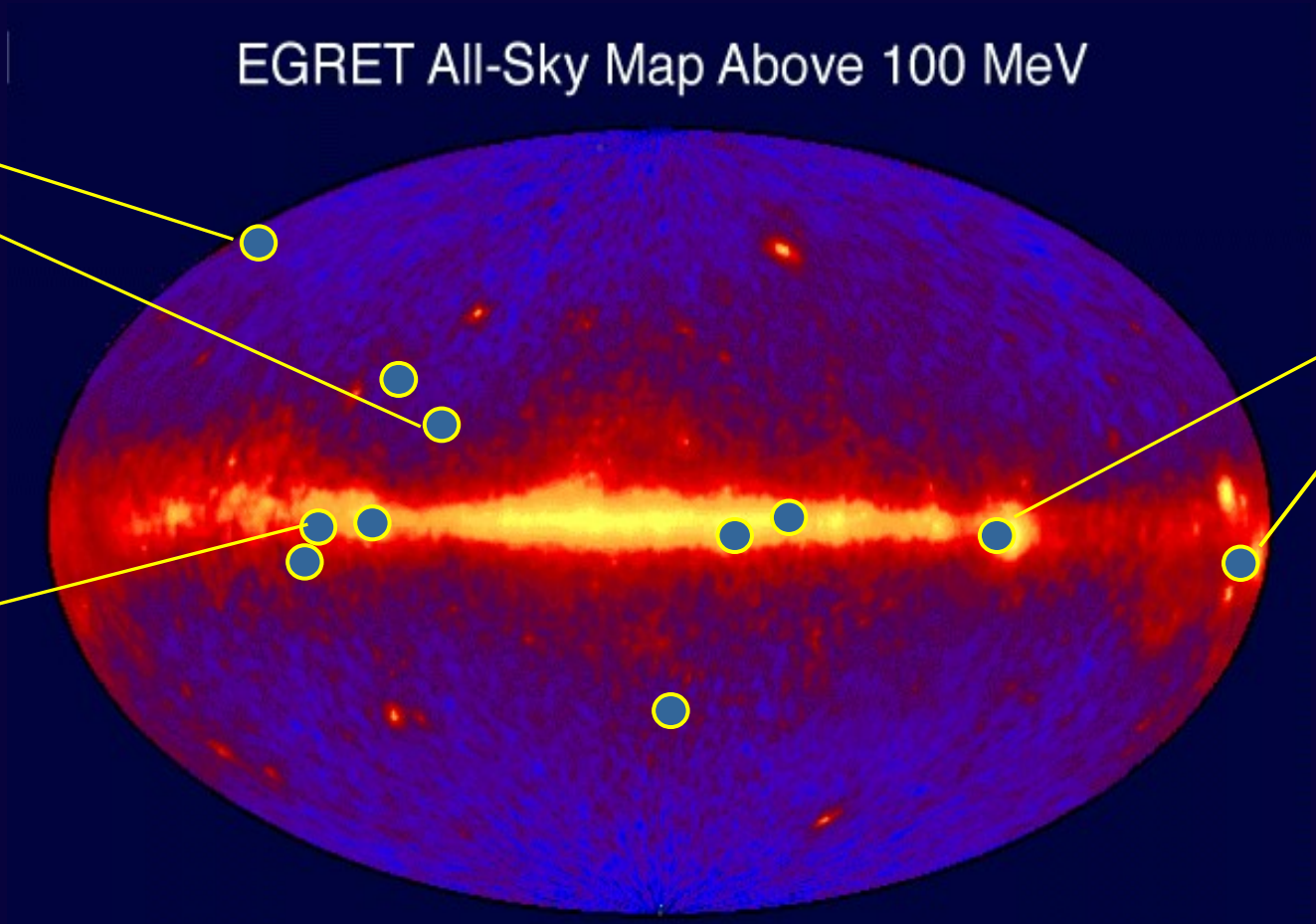


Extreme Universe

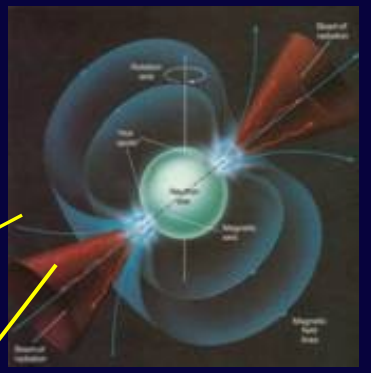
AGN

SNR

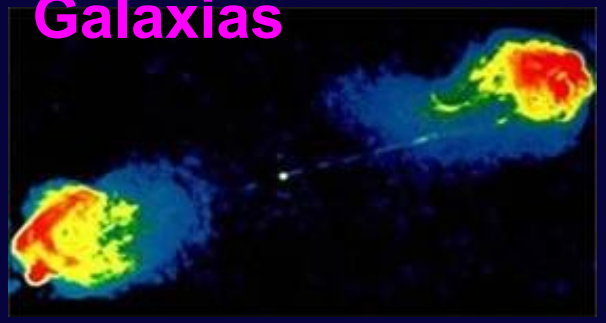




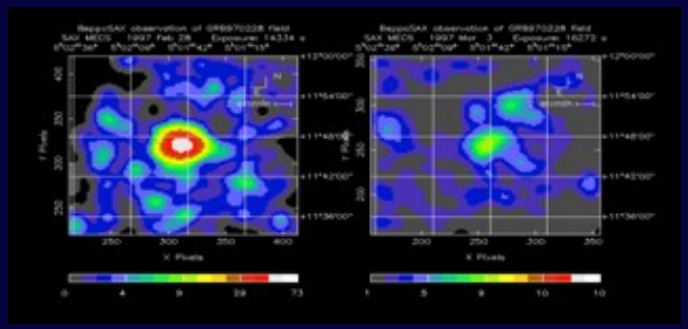
Pulsares

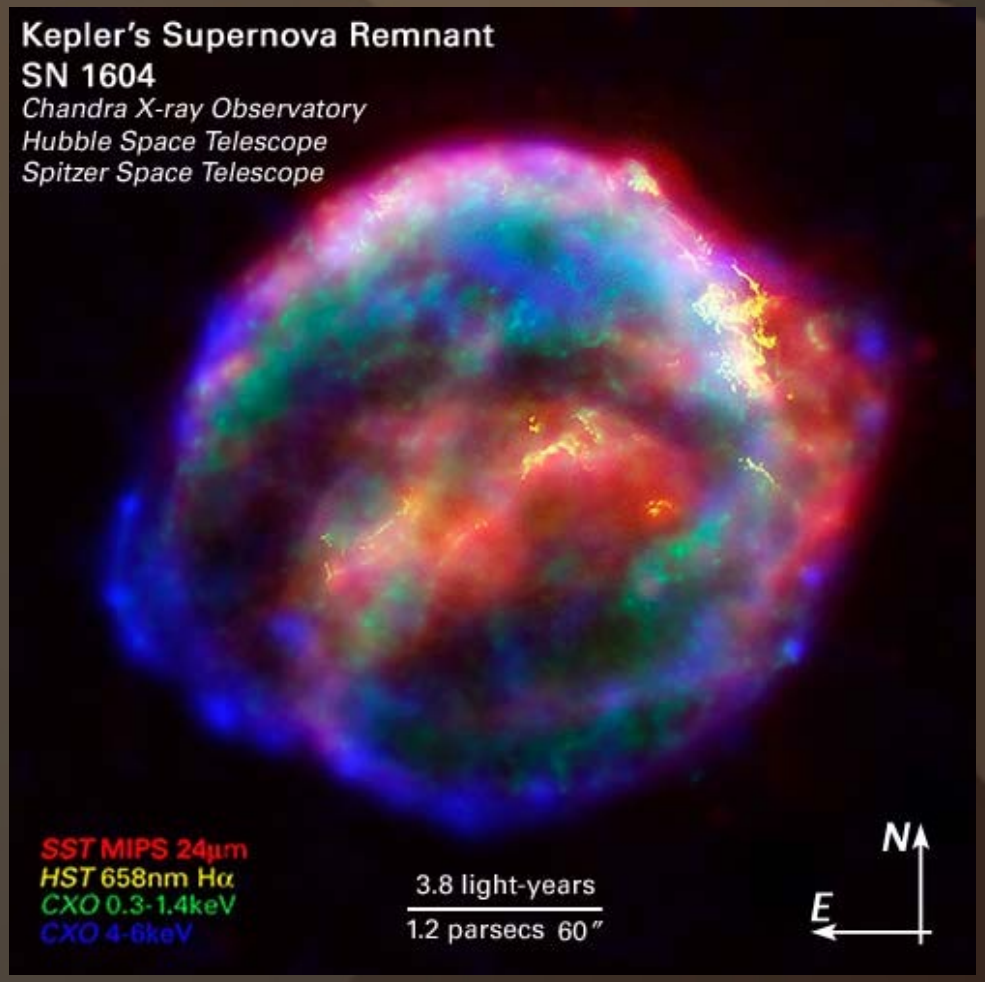


Radio Galaxias



GRB

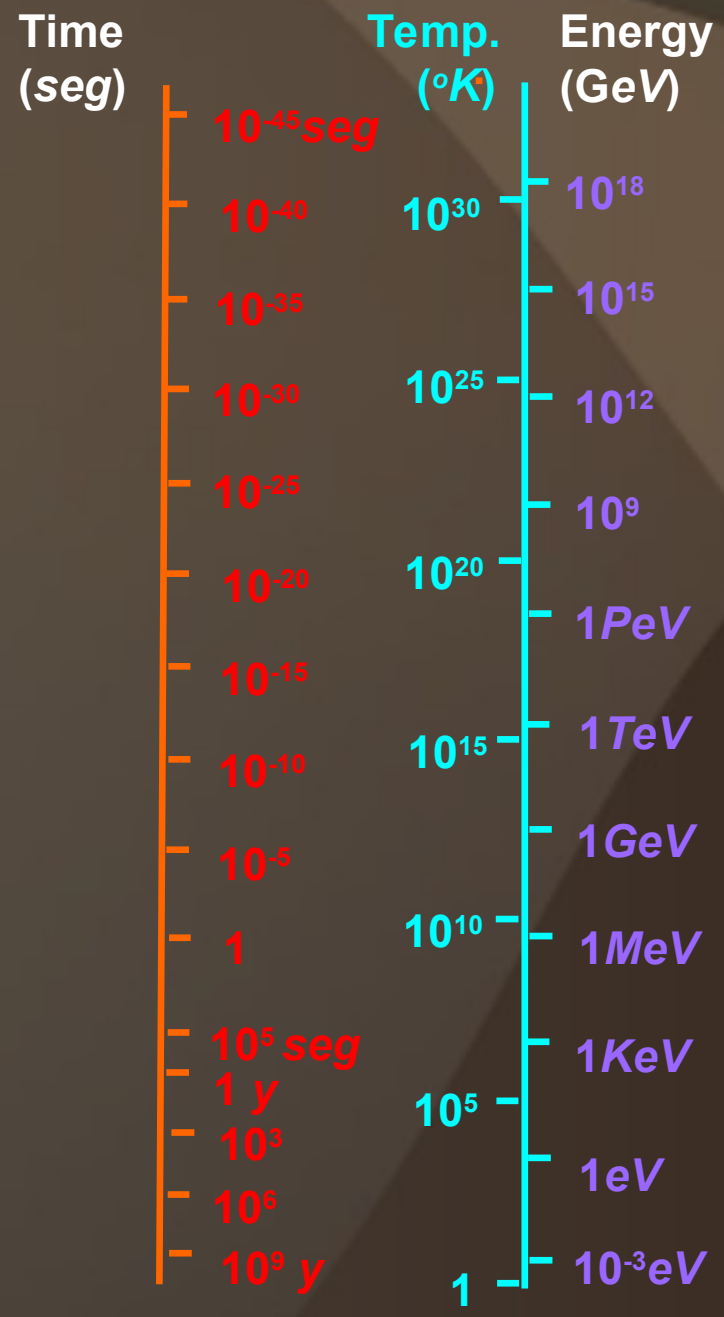


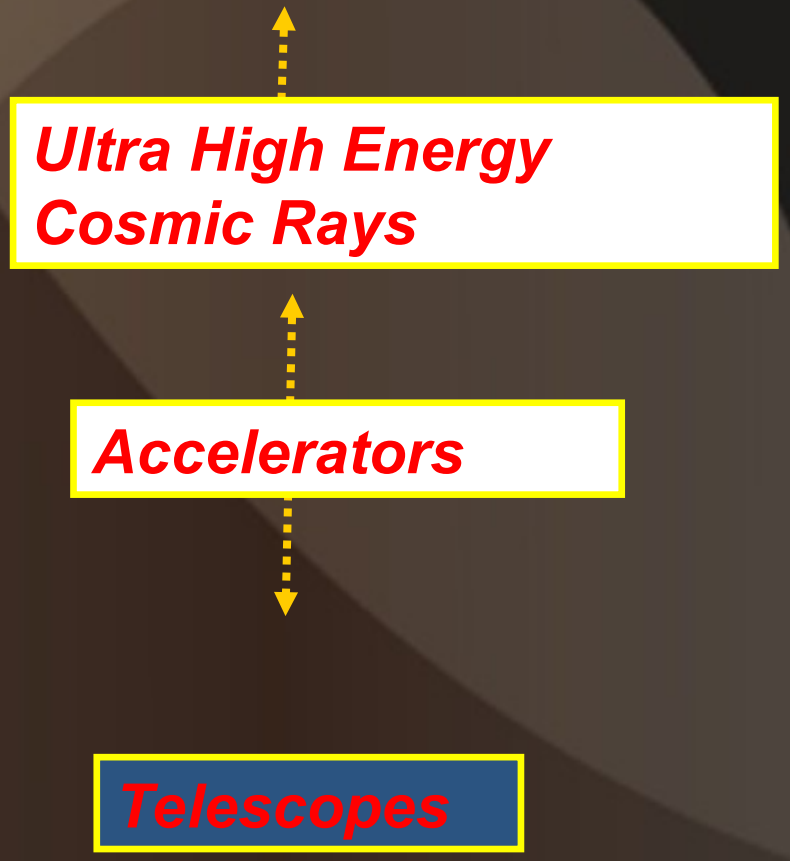


Supernova remnant

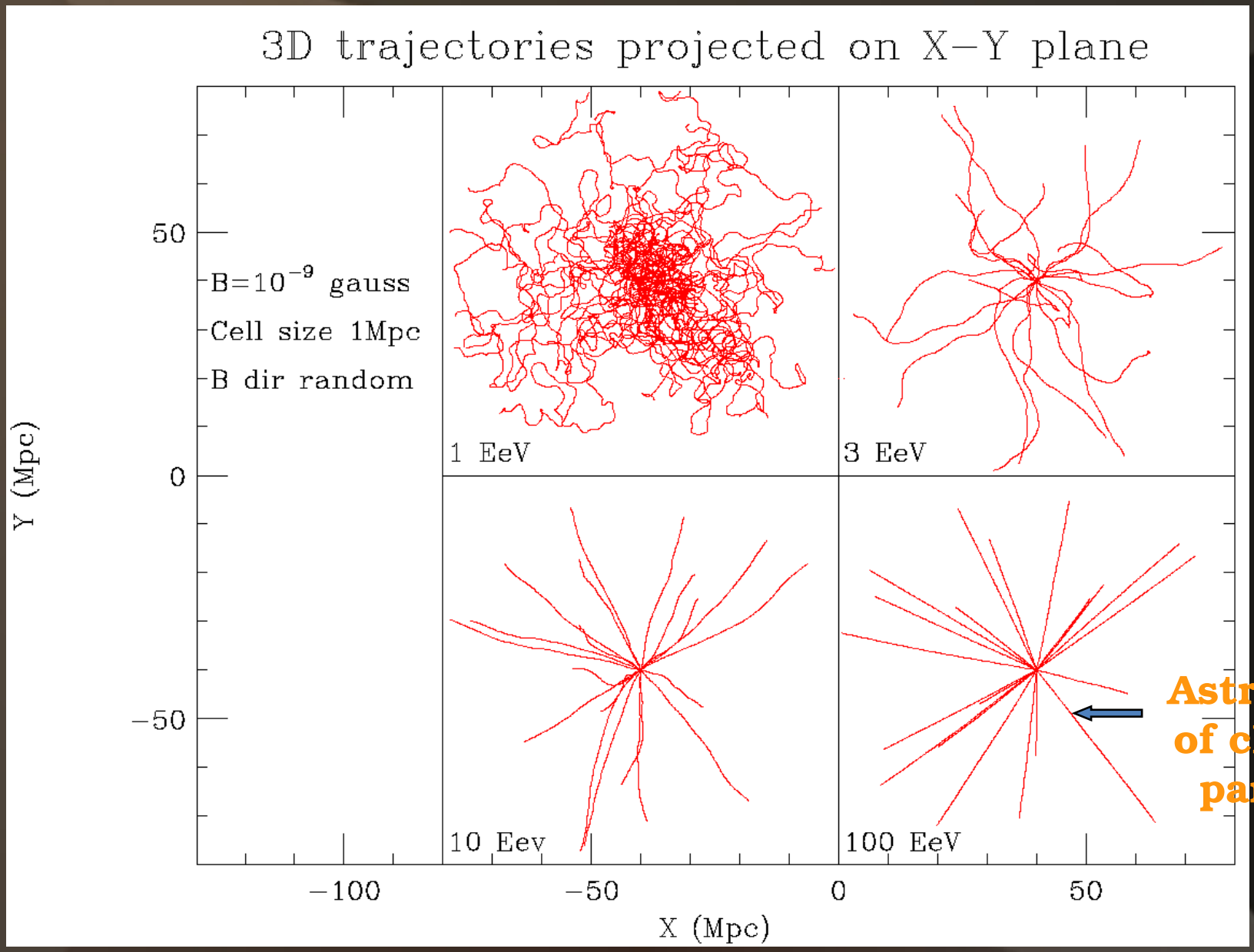
Crab Nebula pulsar

Tools to explore the Primitive Universe





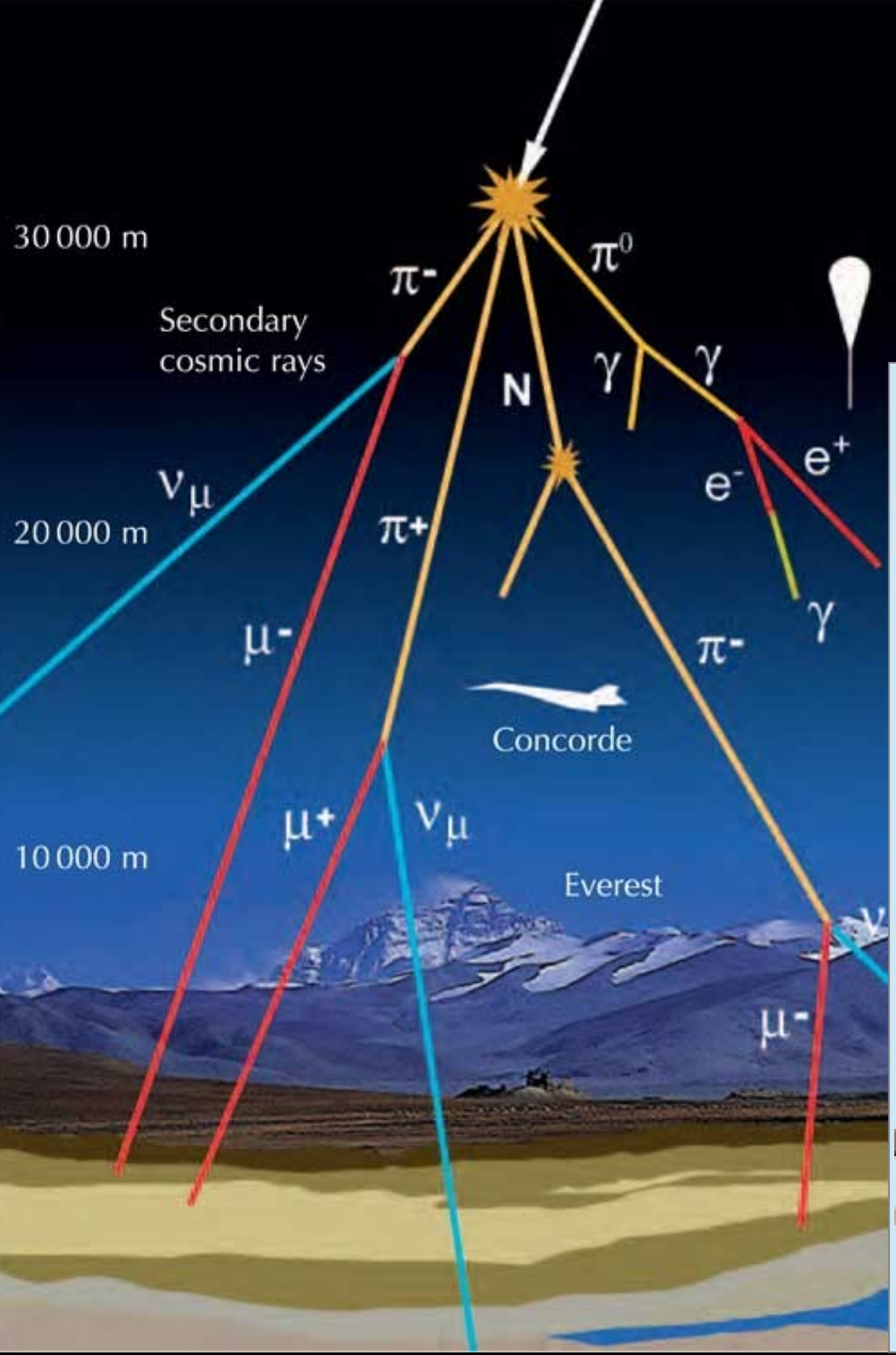
Charged Particles Astrophysics

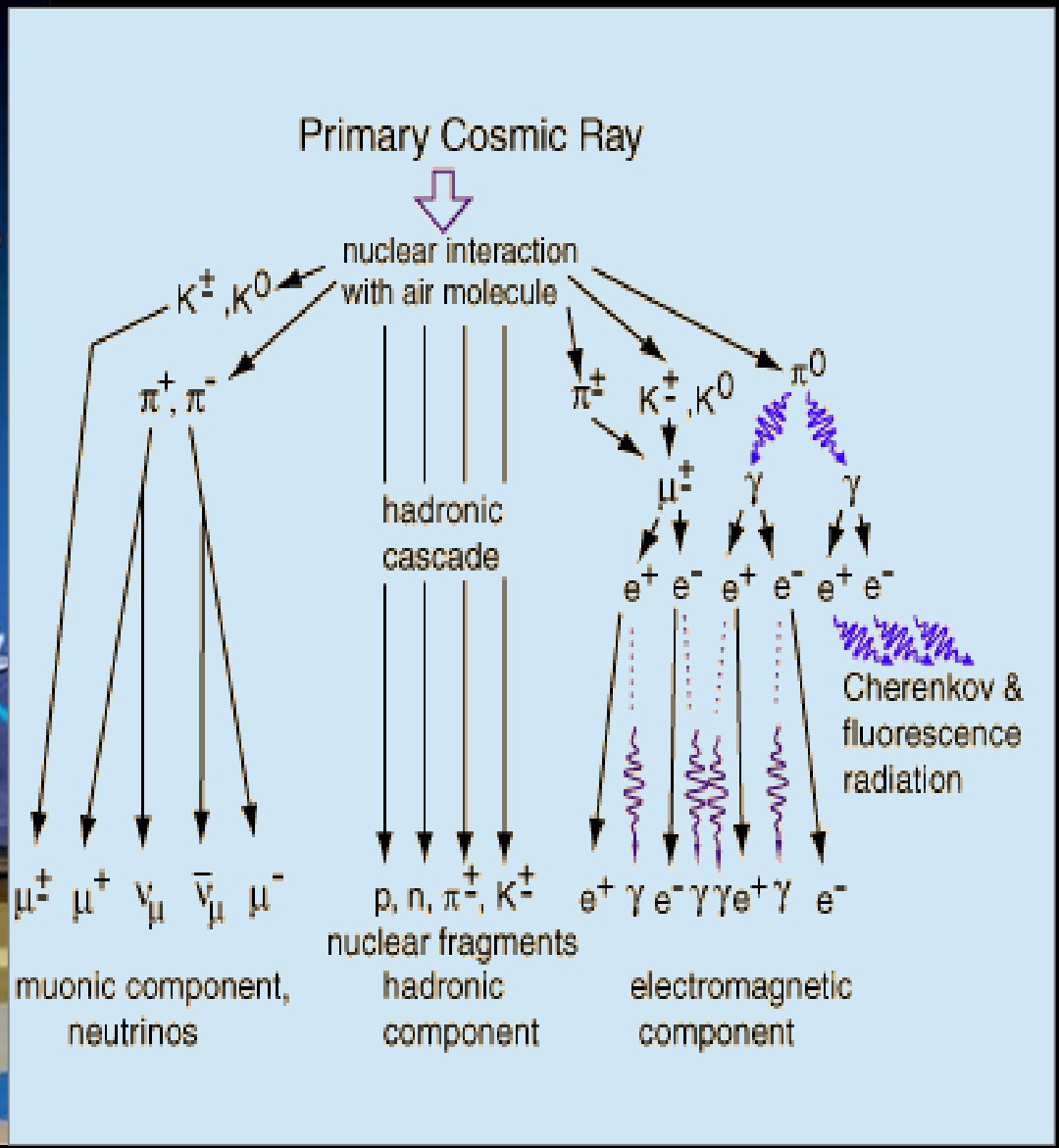


Astronomy of charged particles

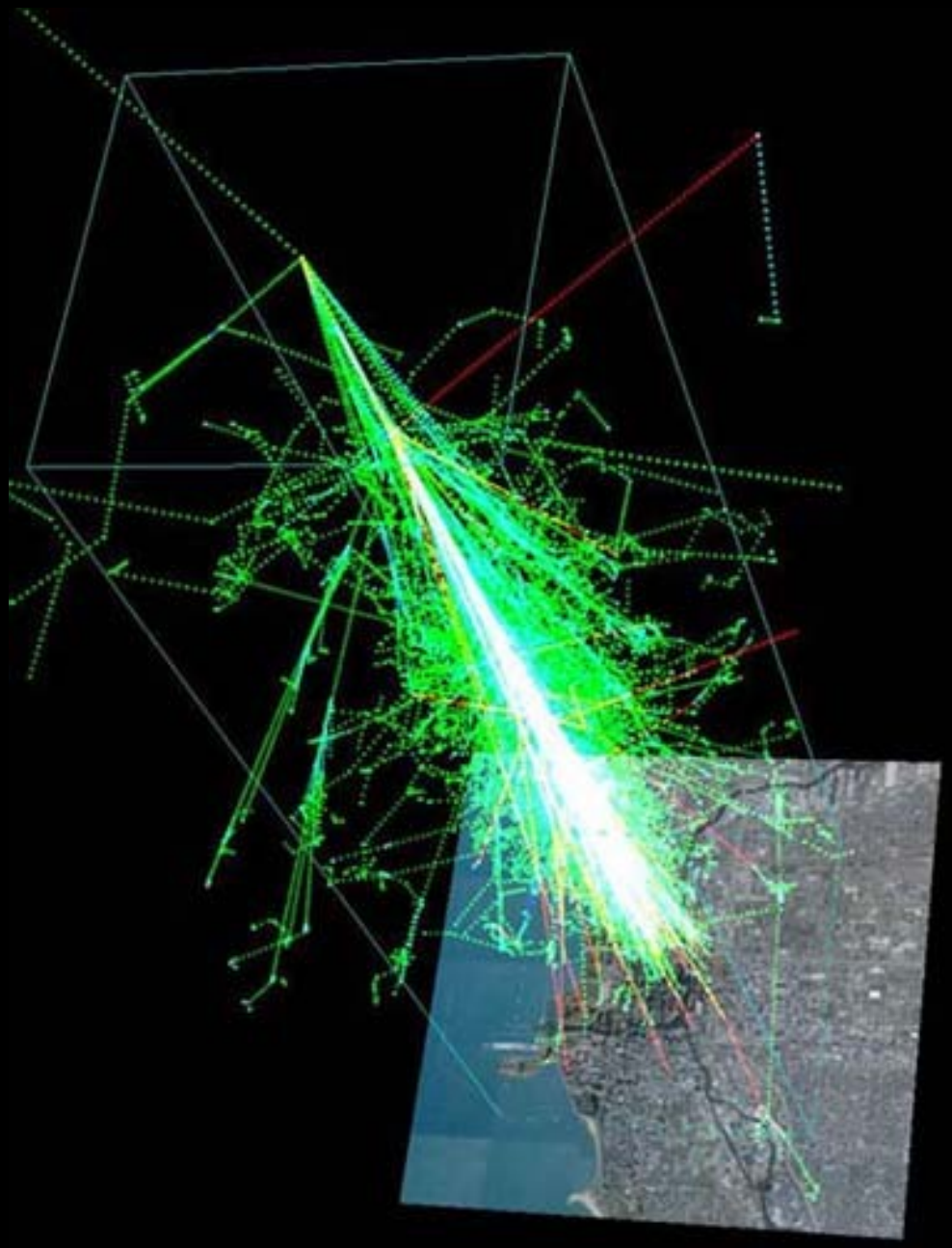
Neutrinos in straight line, pointing the source

Composition





Extened atmospheric showers

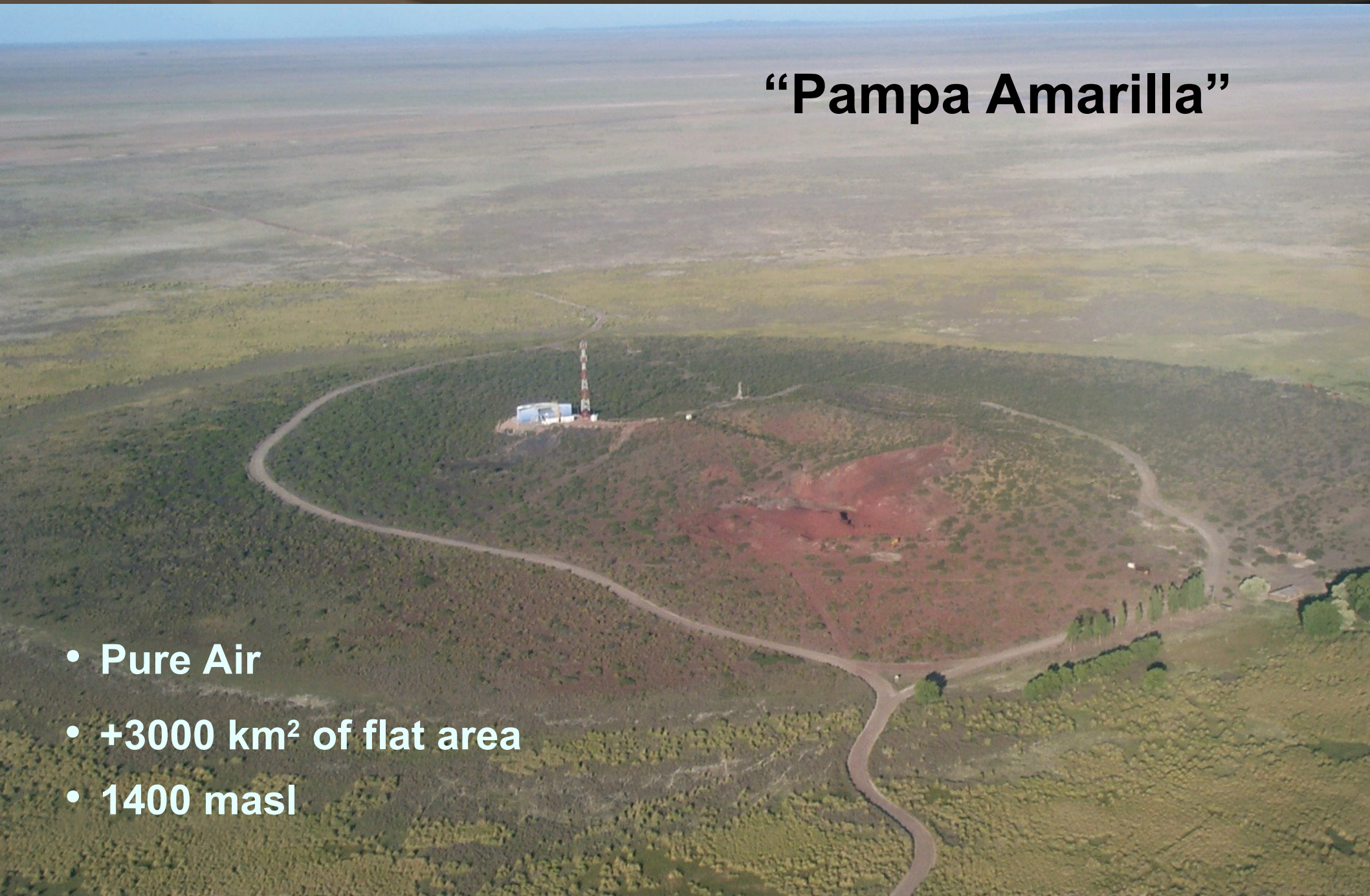


At high energies, the flux is so low that direct detection is almost impossible.

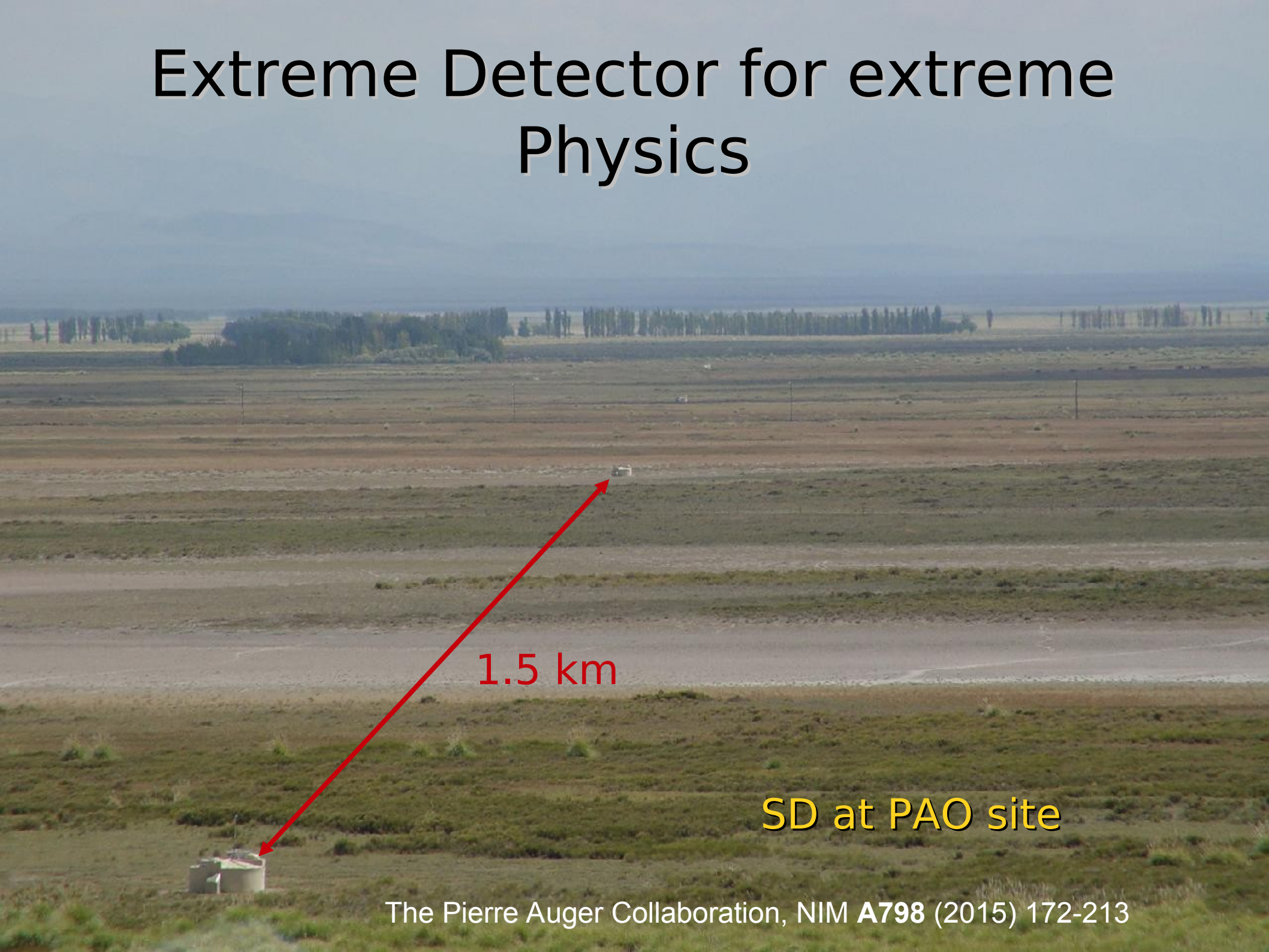
Indirect observations

Cascades of secondary particles are produced by interaction of RC with air molecules

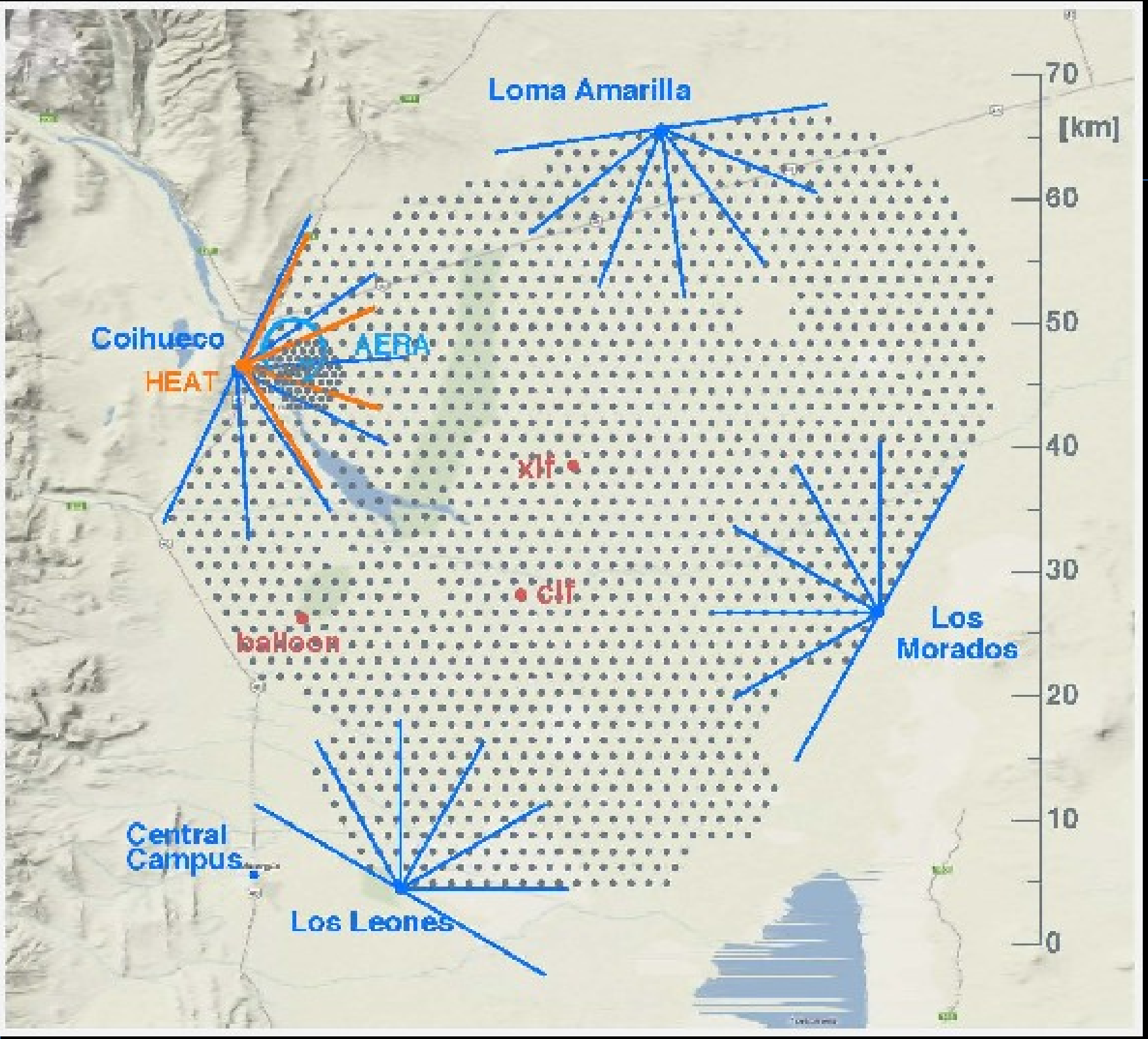
One site: Malargüe - Mendoza



Extreme Detector for extreme Physics



The Pierre Auger Collaboration, NIM **A798** (2015) 172-213


Loma Amarilla
Coihueco
AERA
HEAT
xlf
clf
balloon
Los Morados
Central Campus
Los Leones
70
[km]
60
50
40
30
20
10
0

Loma Ama
Coihueco
AERA
HEAT
xlf
clf
balloon
Los Morados
Central Campus
Los Leones
40
30
20
10

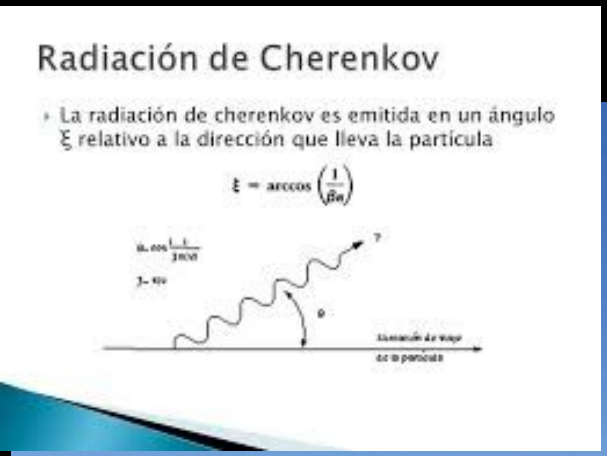
~ (50x60) km = 3000 km²

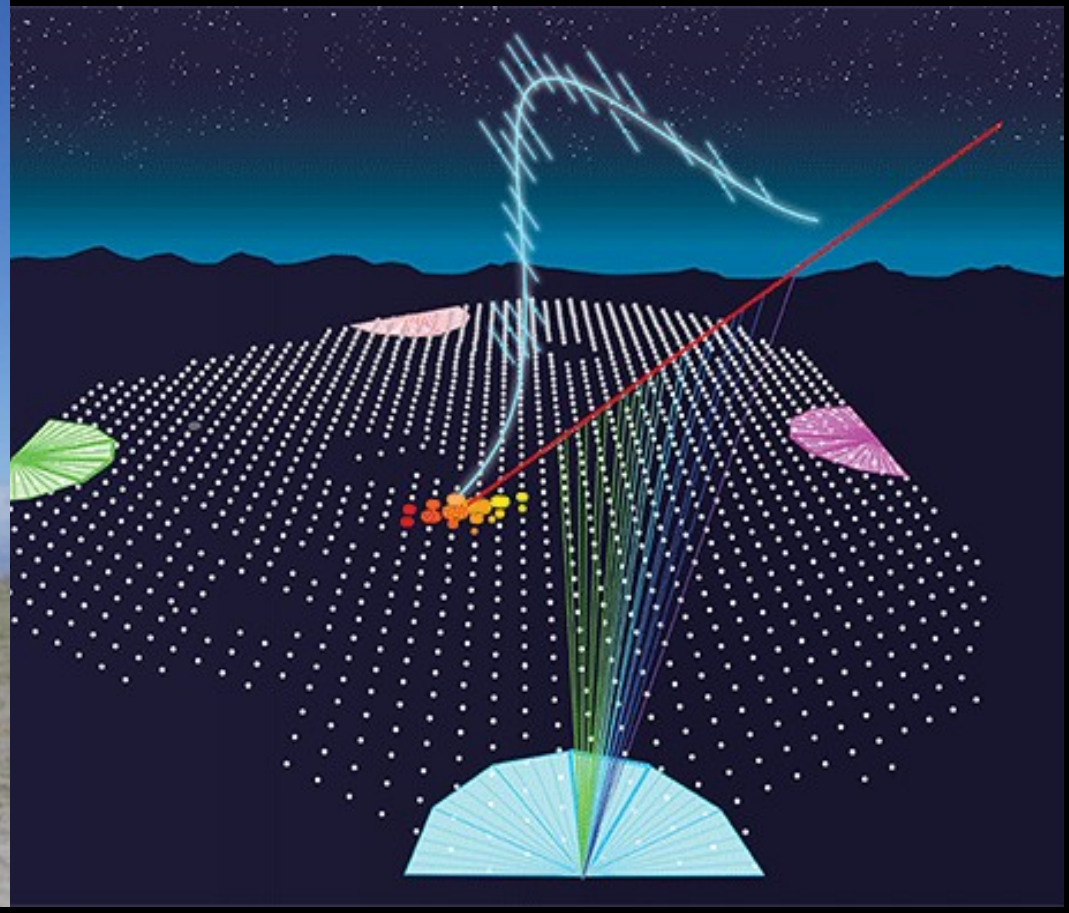
1660 Cherencov Detectors (16600 m² detection area)

27 Atmospheric Fluorescence Detectors

Instalation of Detectors

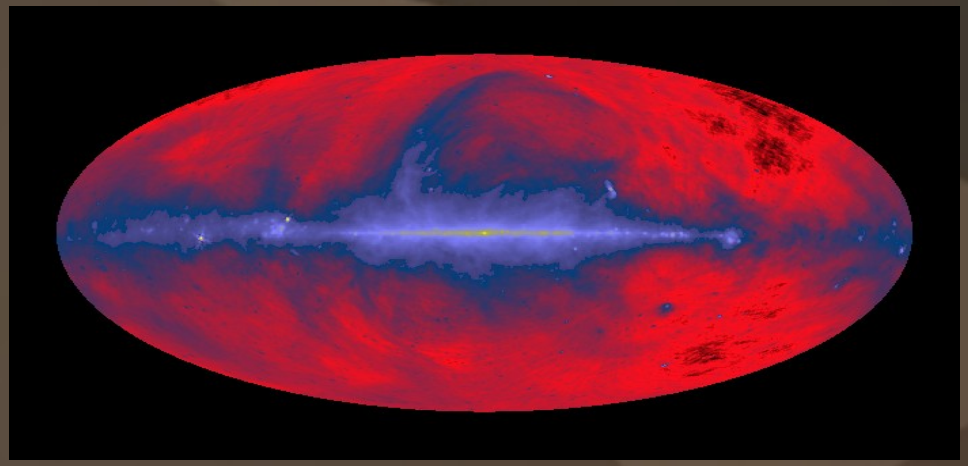
Auger Detectors



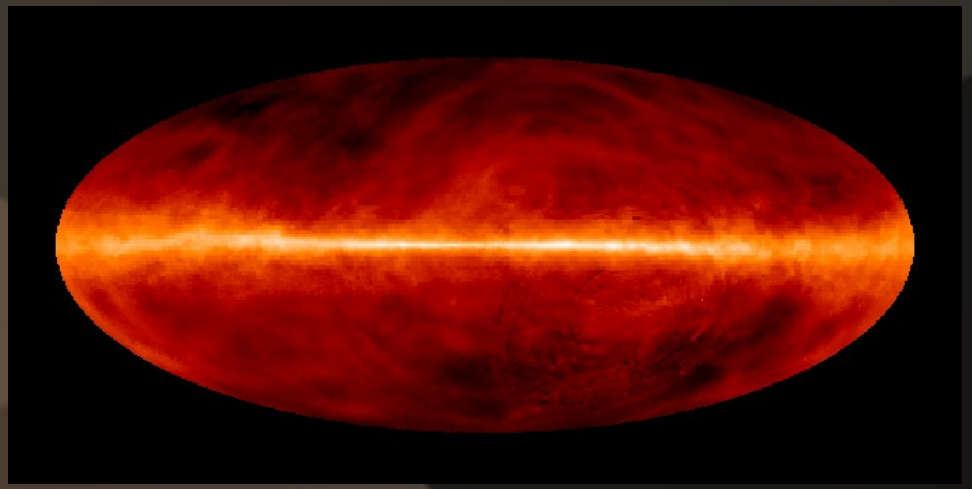


PAO is an hybrid detector. Flourescence Detector: 4 edificios, 27 telescopios) y
Surface detector: 1660 detectores in 3000 km^2

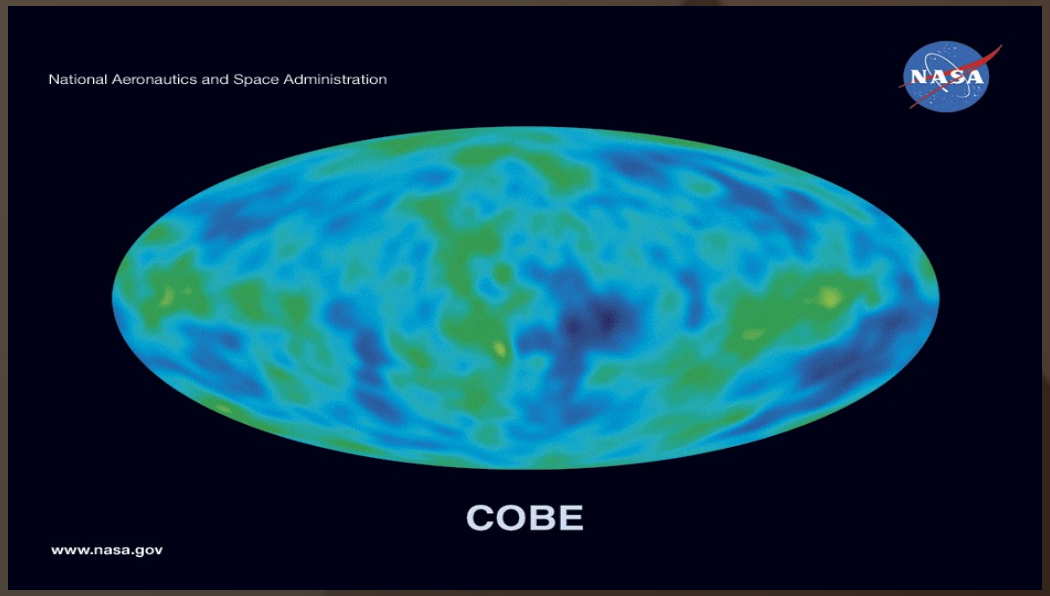
A Multiwavelengh and Multimessenger approach to the knowledge of the Cosmos



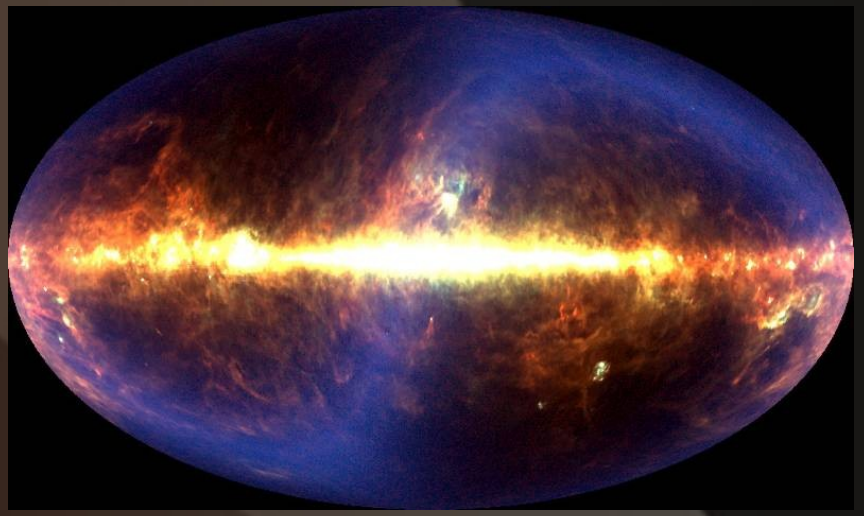
Radio 408MHz



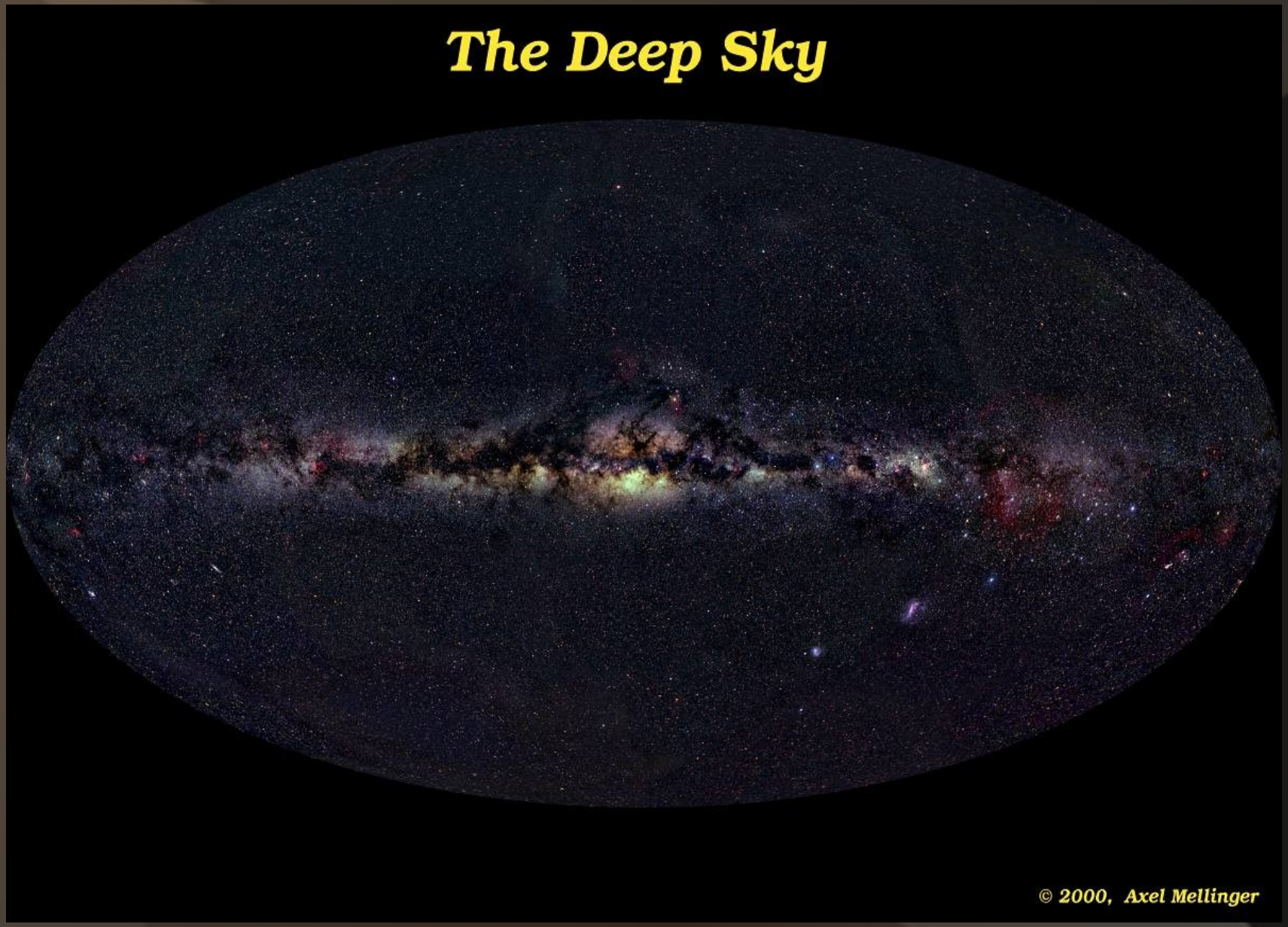
Radio 1420 Mhz
21 cm



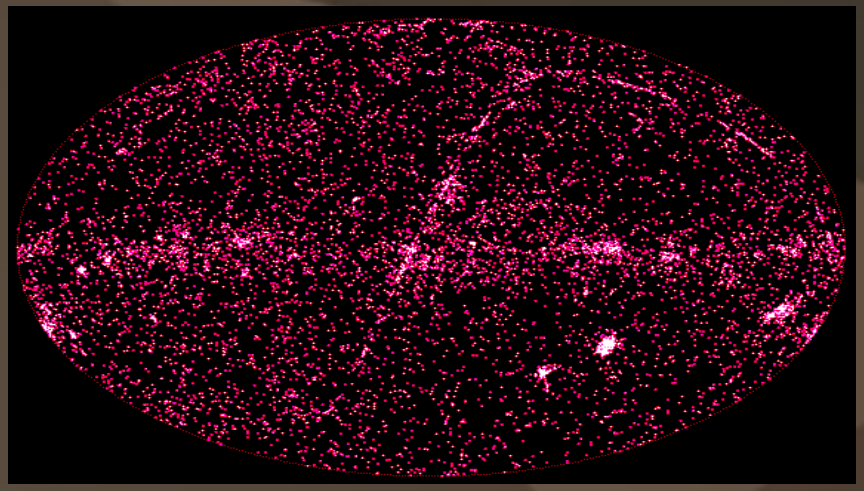
Microwaves



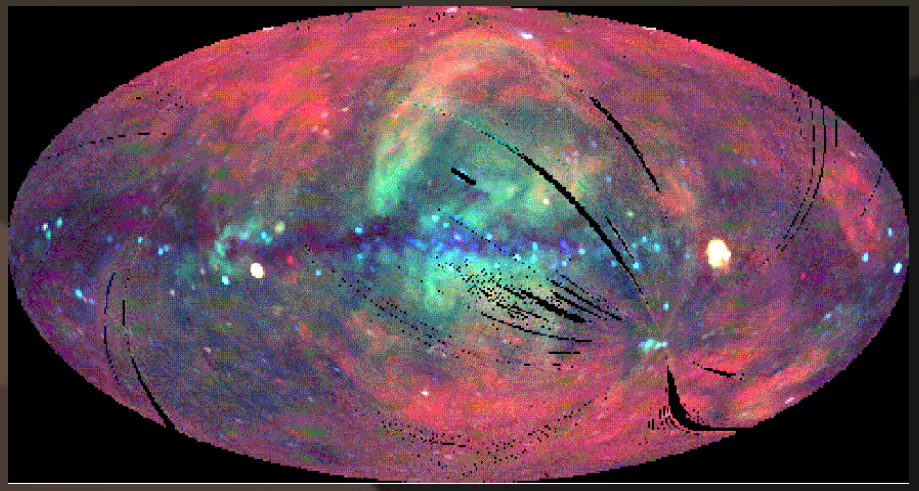
Infrared



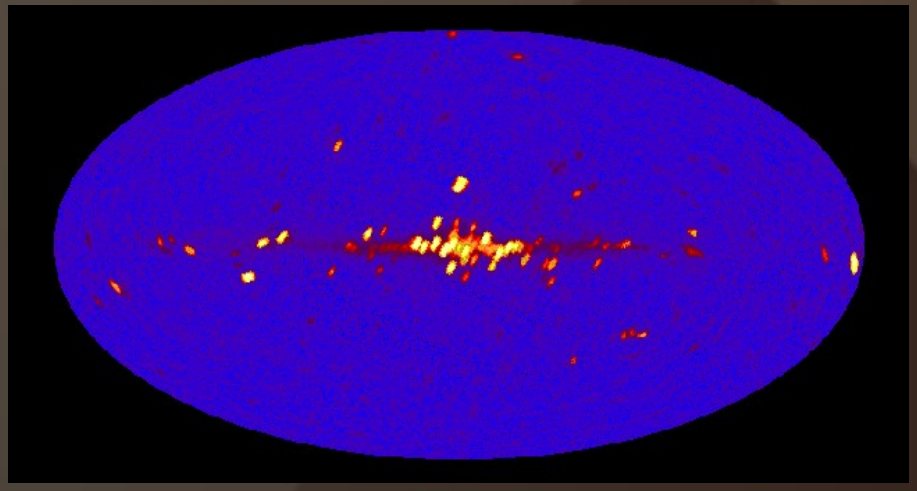
Visible – 360 a 780 nm



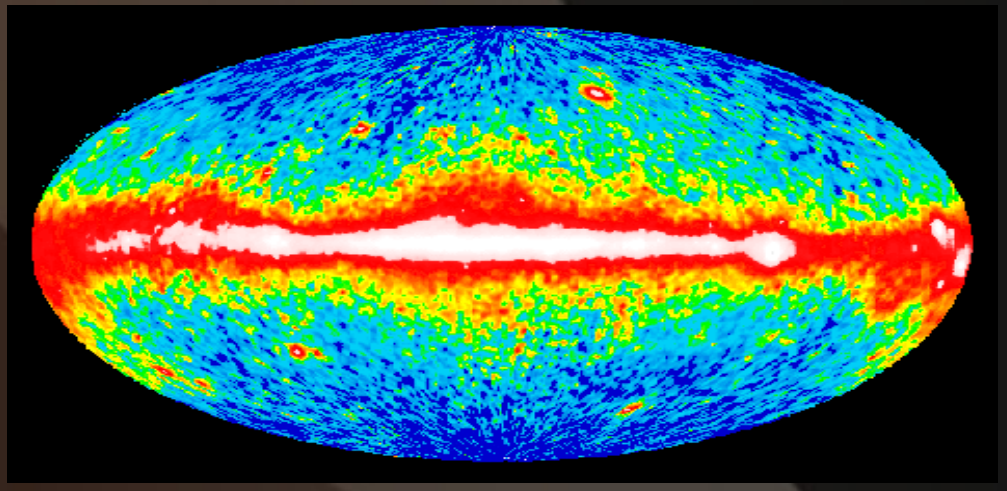
Ultraviolet



X-0.25, 075, 1.5 keV

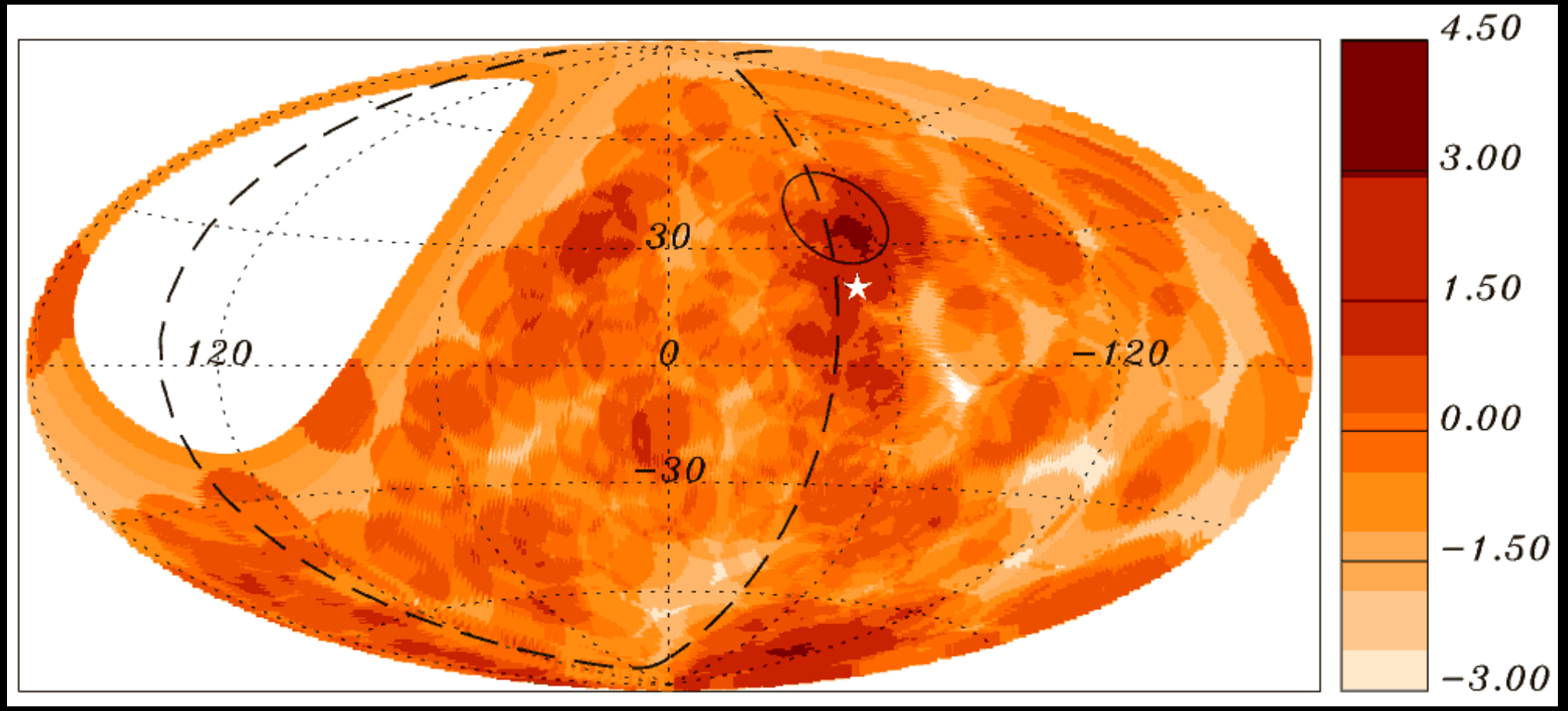


X- 2-10 keV



Gamma Rays

Search for UHECR Anisotropies

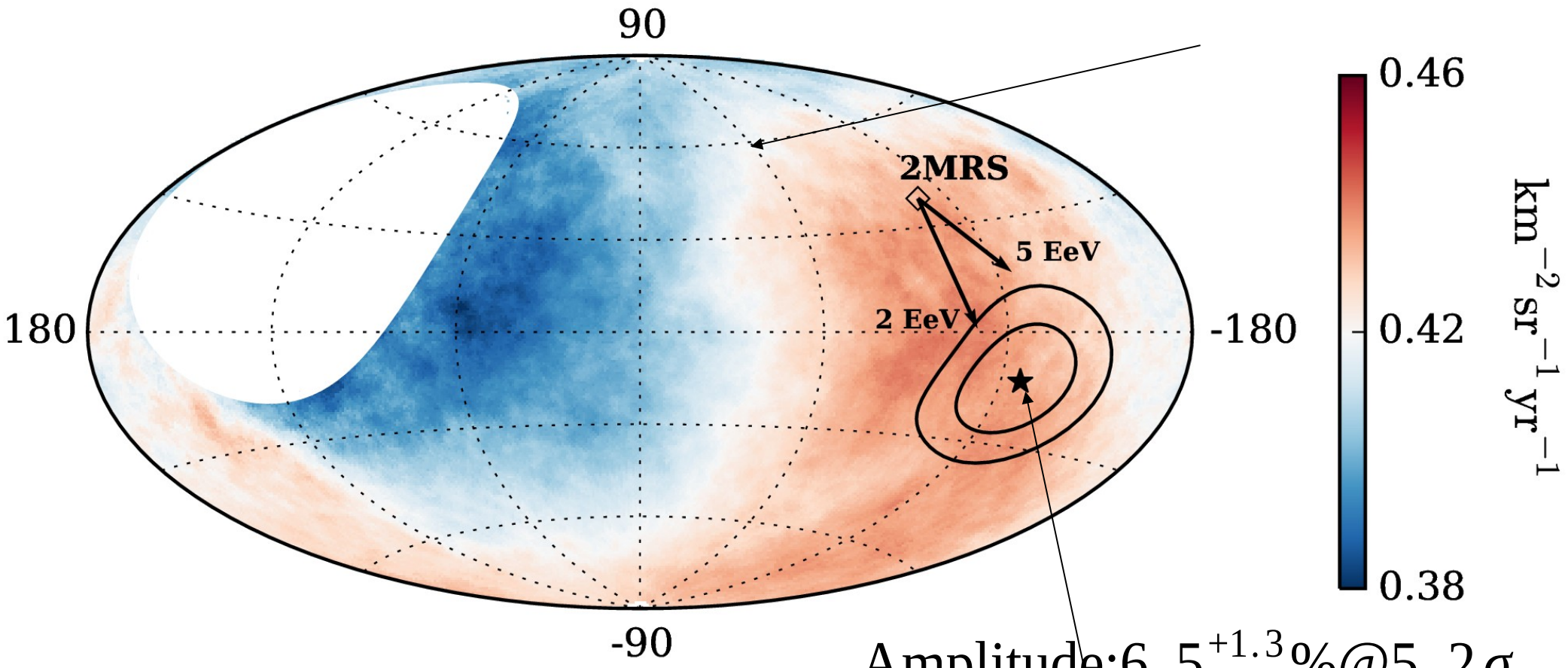


Significatibe excesses in 12° around E >54 EeV events

The Pierre Auger Collaboration, ApJ **804**(2015)15

50 year-old mystery has been solved: dipole at UHECR Flux Map atE > 8 EeV

The Pierre Auger Collaboration, Science **357**(2017)1266, arXiv:1709.07321 [astro-ph.HE]



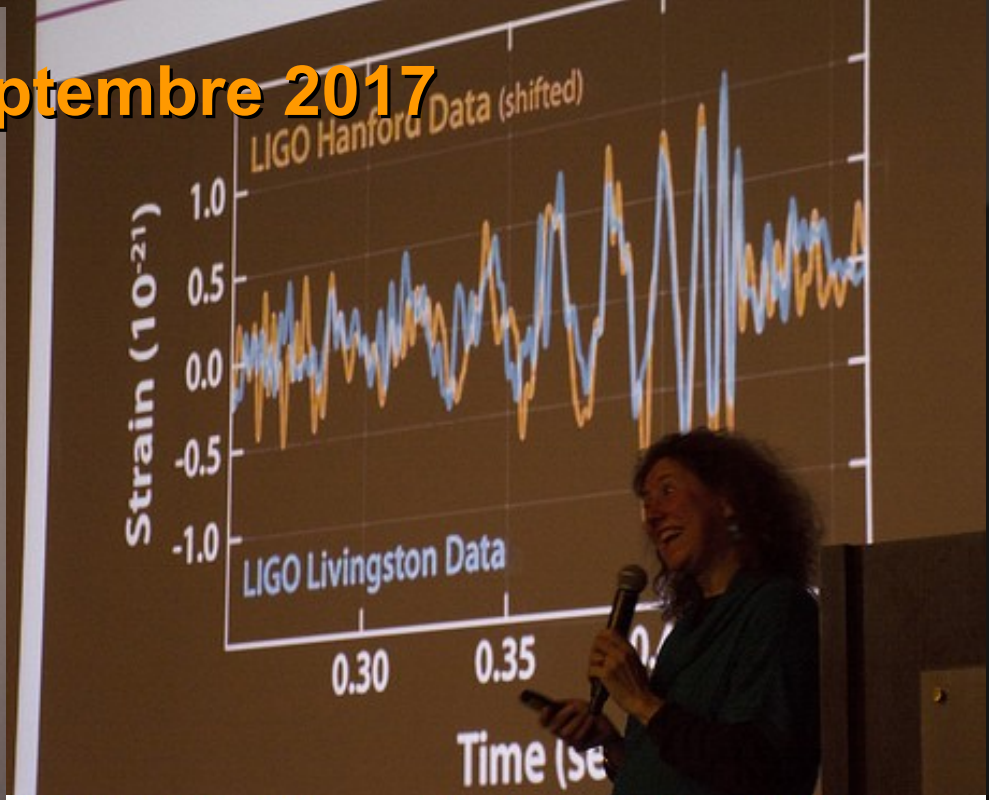
$$\text{Amplitude: } 6.5^{+1.3}_{-0.9}\%@5.2\sigma$$

125° from GC → Extra Galactic Origin Of CR

$$\alpha_d = 100^\circ \pm 10^\circ; \delta_d = -24^{\circ\,+12^\circ}_{-13^\circ}$$

3AAA meeting – Septembre 2017

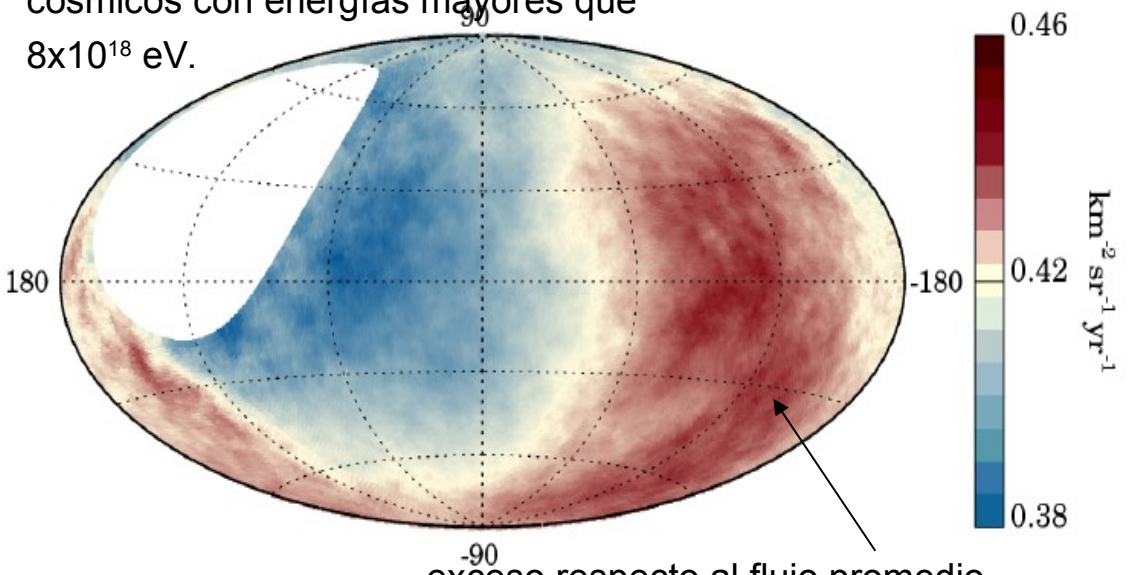
Gabriela González LIGO



Esteban Roulet,
CONICET-IB

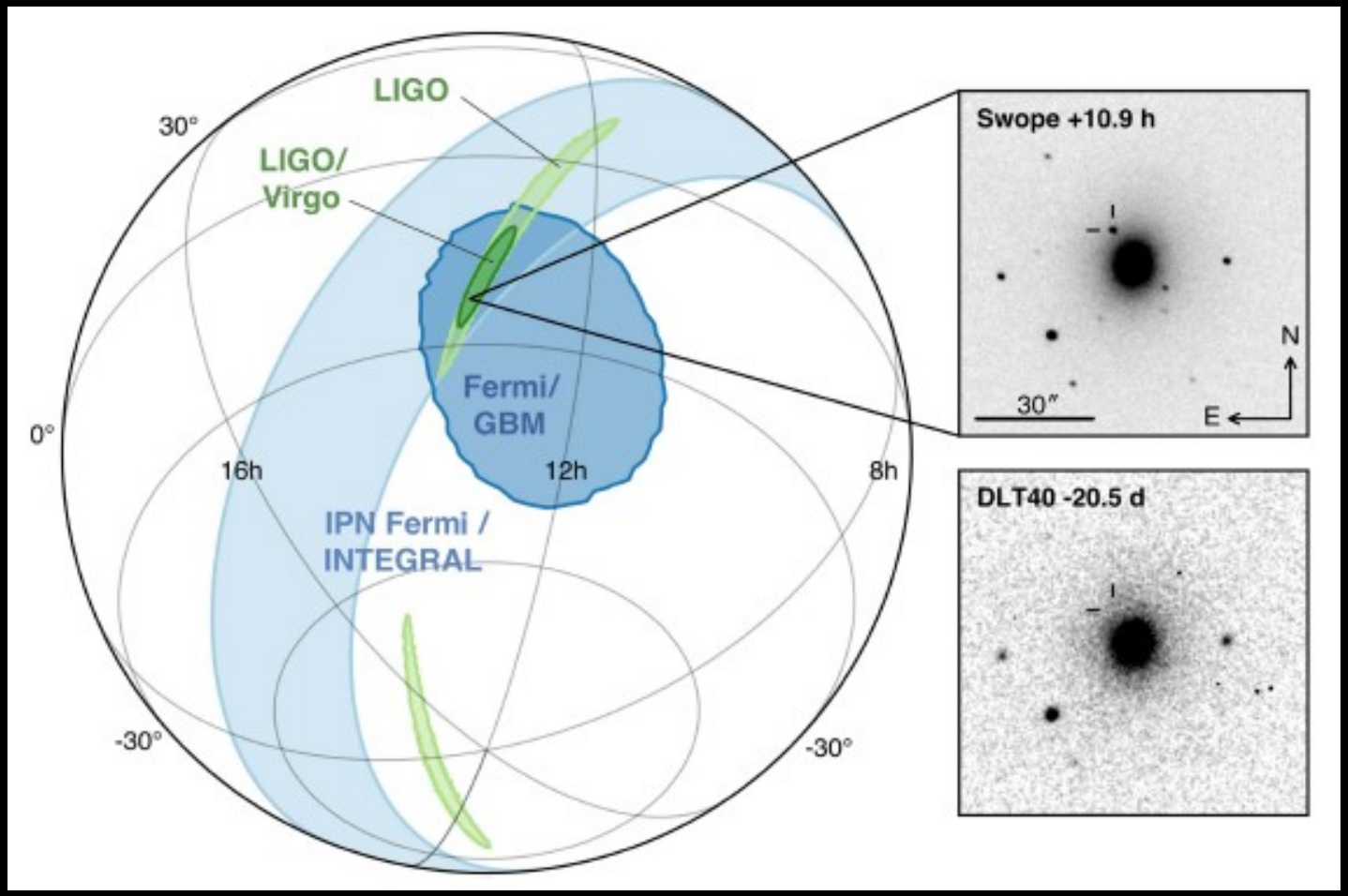
EMBARGADO HASTA LAS 3:00 PM hora argentina del Jueves 21 de septiembre 2017

Mapa en coordenadas galácticas del flujo medido de rayos cósmicos con energías mayores que 8×10^{18} eV.



exceso respecto al flujo promedio,

Neutron Stars Collision



Las Campanas -Chile

Discovery in GW on August 17, 2017, at exactly 12:41. Less than 2 seconds later, Fermi / NASA records the gamma-ray burst. Around 22:00 GMT, the telescope arrangement in Chile determined the exact location: NGC 4993, 130 million light years from Earth.

Pierre Auger, ANTARES, IceCube: Searching for neutrinos emision from GW170817 merging

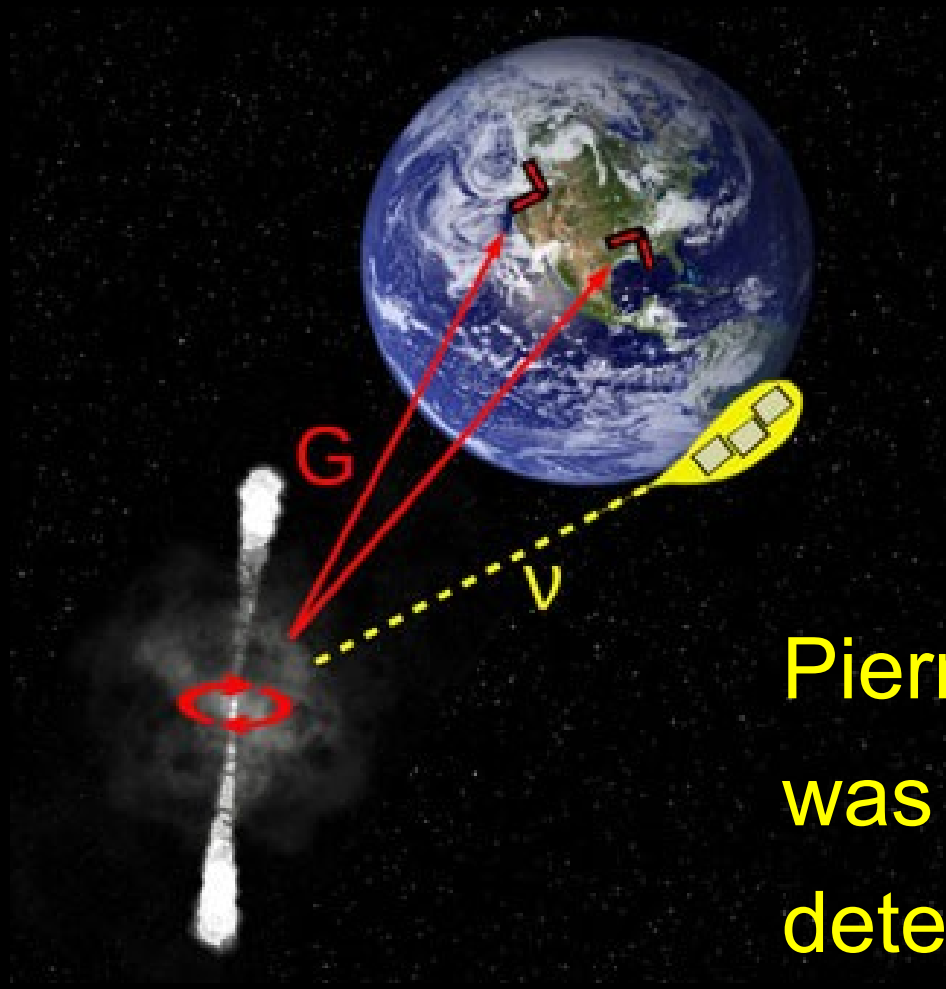


Illustration of the merging binary neutron star GW170817 emitting gravitational waves observed at the two LIGO sites in the United States. The neutrino detection channel brushing the Earth is observed.

Pierre Auger in Argentina was at the right position for detection!

THE ASTROPHYSICAL JOURNAL LETTERS, 848:L12 (59pp), 2017 October 20 https://doi.org/10.3847/2041-8213/aa91c9

OPEN ACCESS

Multi-messenger Observations of a Binary Neutron Star Merger

LIGO Scientific Collaboration and Virgo Collaboration, Fermi GBM, INTEGRAL, IceCube Collaboration, AstroSat Cadmium Zinc Telluride Imager Team, IPN Collaboration, The Insight-Hxmt Collaboration, ANTARES Collaboration, The Swift Collaboration, AGILE Team, The 1M2H Team, The Dark Energy Camera GW-EM Collaboration and the DES Collaboration, The DLT40 Collaboration, GRAWITA: GRAvitational Wave Inaf TeAm, The Fermi Large Area Telescope Collaboration, ATCA: Australia Telescope Compact Array, ASKAP: Australian SKA Pathfinder, Las Cumbres Observatory Group, OzGrav, DWF (Deeper, Wider, Faster Program), AST3, and CAASTRO Collaborations, The VINROUGE Collaboration, MASTER Collaboration, J-GEM, GROWTH, JAGWAR, Caltech-NRAO, TTU-NRAO, and NuSTAR Collaborations, Pan-STARRS, The MAXI Team, TZAC Consortium, KU Collaboration, Nordic Optical Telescope, ePESSTO, GROND, Texas Tech University, SALT Group, TOROS: Transient Robotic Observatory of the South Collaboration, The BOOTES Collaboration, MWA: Murchison Widefield Array, The CALET Collaboration, IKI-GW Follow-up Collaboration, H.E.S.S. Collaboration, LOFAR Collaboration, LWA: Long Wavelength Array, HAWC Collaboration, The Pierre Auger
eam, Pi of the Sky Collaboration, The Chandra Team at McGill University, DFN:
olution Universe Survey, RIMAS and RATIR, and SKA South Africa/MeerKAT
e end matter for the full list of authors.)

2017 October 6; accepted 2017 October 6; published 2017 October 16

BBC Ingresar Menú Buscar

MUNDO

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La impresionante colisión de dos estrellas de neutrones que provocaron las ondas gravitacionales que predijo Einstein

Redacción
BBC Mundo Ciencia

16 octubre 2017 Compartir

La ilustración muestra las ondas creadas por este violento fenómeno.

Principales noticias

3 claves del éxito económico del país que más crece en América del Sur
Ha crecido mucho más que Estados Unidos y ha logrado hacerle frente a la caída en el precio de los recursos naturales que golpeó duramente a América Latina. Ahorró en la época de las vacas gordas y ahora resiste mejor que otros.
25 octubre 2017

"Me casé a los 13 años y sentía que era una esclava": los estremecedores casos de matrimonios infantiles en Estados Unidos
25 octubre 2017

Los mejores lugares para viajar en 2018 según Lonely Planet (y el país número 1 está en América Latina)
25 octubre 2017

Más noticias

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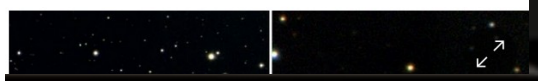
CIENCIA ▸ AVANCE EN ASTRONOMÍA

Por primera vez, observan el choque de dos estrellas de neutrones

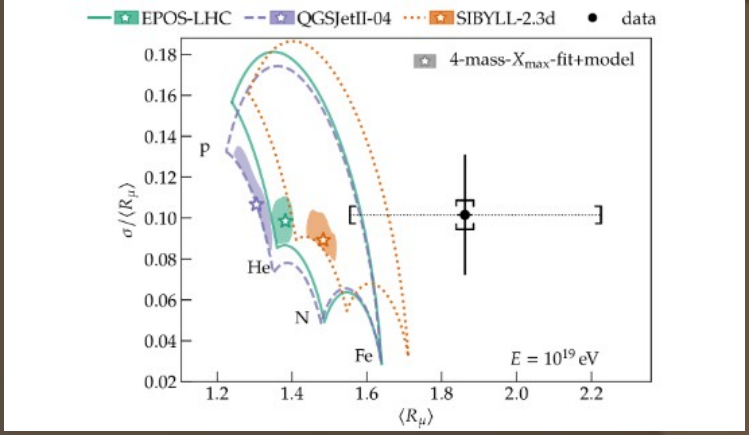
Los detectores de ondas gravitacionales LIGO y Virgo descubrieron el fenómeno y su localización para que lograron verlo 60 telescopios; entre ellos, el de Bosque Alegre de Córdoba.

16|10|17 11:05

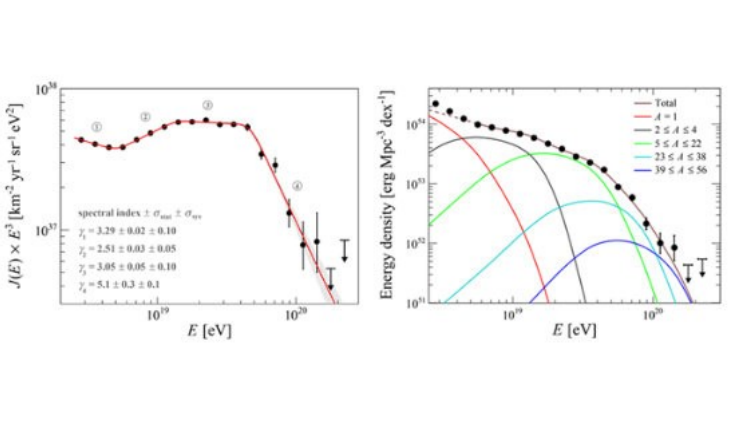
Farré, Cecilia Cecilia Farré



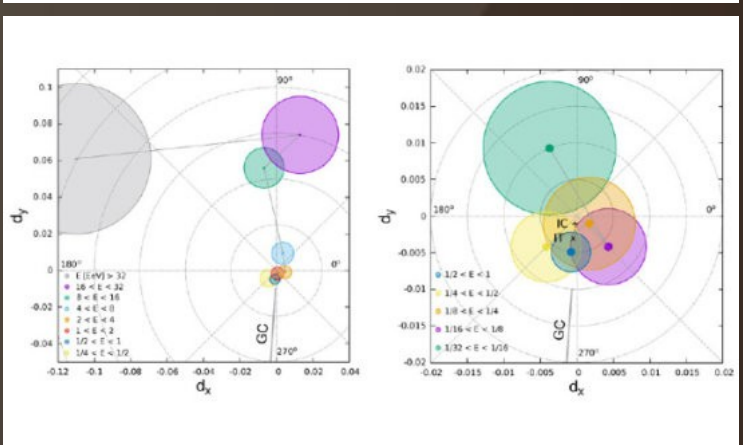
PAO Highlights



2021. First measurement of the fluctuations in the muon content of air showers at ultra-high energy

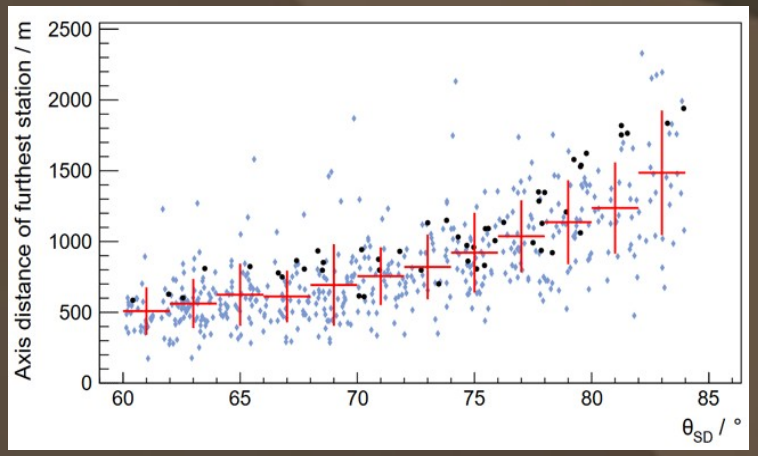


2020. Most precise measurement of the cosmic-ray energy spectrum at ultra-high energies

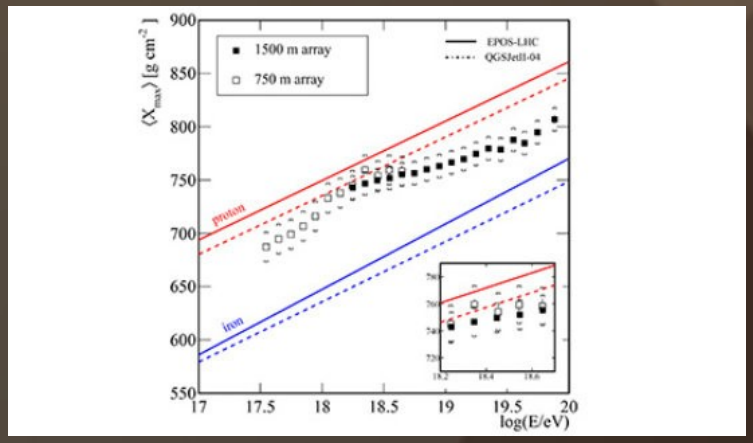


2020. Cosmic-ray anisotropies in right ascension measured by the Pierre Auger Observatory

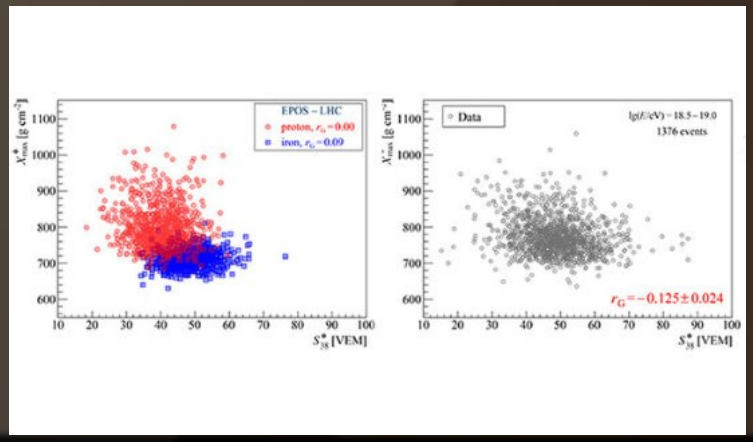
PAO Highlights



2018. Observation of inclined EeV air showers with the radio detector of the Pierre Auger Observatory (150 detectors, 30-80MHz)



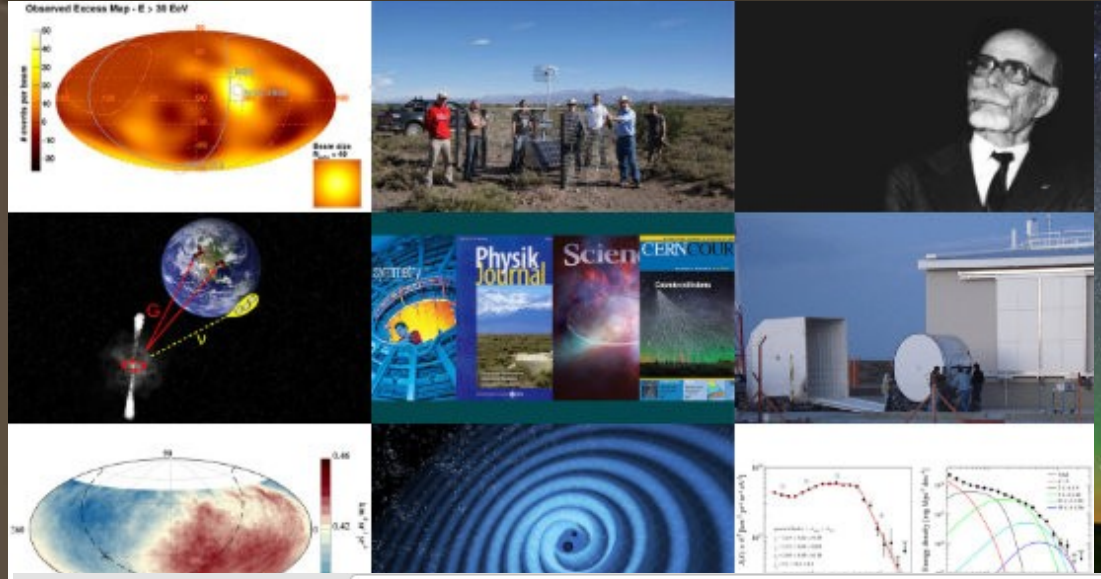
2017. Inferences on Mass Composition and Tests of Hadronic Interactions from 0.3 to 100 EeV using the water-Cherenkov Detectors of PAO



2016. Evidence for a mixed mass composition at the 'ankle' in the cosmic ray spectrum

Social Impact

Stamp Argentina 2007



https://opendata.auger.org

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Auger Open Data

Datasets Visualization Analysis

The Pierre Auger 2021 Open Data is the public release of 10% of the Pierre Auger Observatory data presented at the 36th International Cosmic Ray Conference held in 2019 in Madison, USA, following the Auger collaboration open data policy.

This website hosts the datasets for download. An online event display is available to explore the released events, and example analysis codes are provided. See below for a brief overview of the Pierre Auger Observatory and of the Auger Open Data.

Datasets

the complete released datasets and their complementary data

Visualize

an online look at the released pseudo raw data

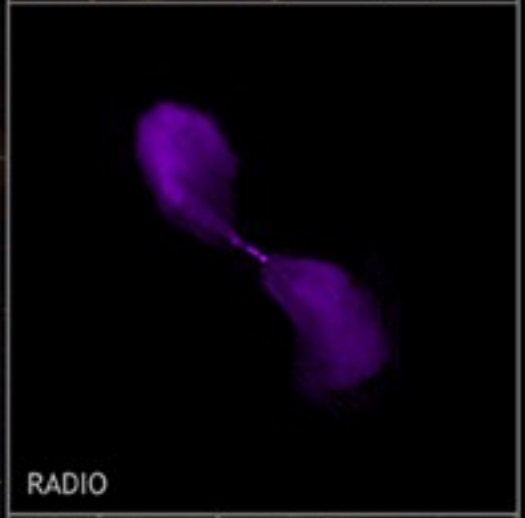
Analyze

example analysis codes in online python notebooks to run on the datasets

Pierre Auger Observatory

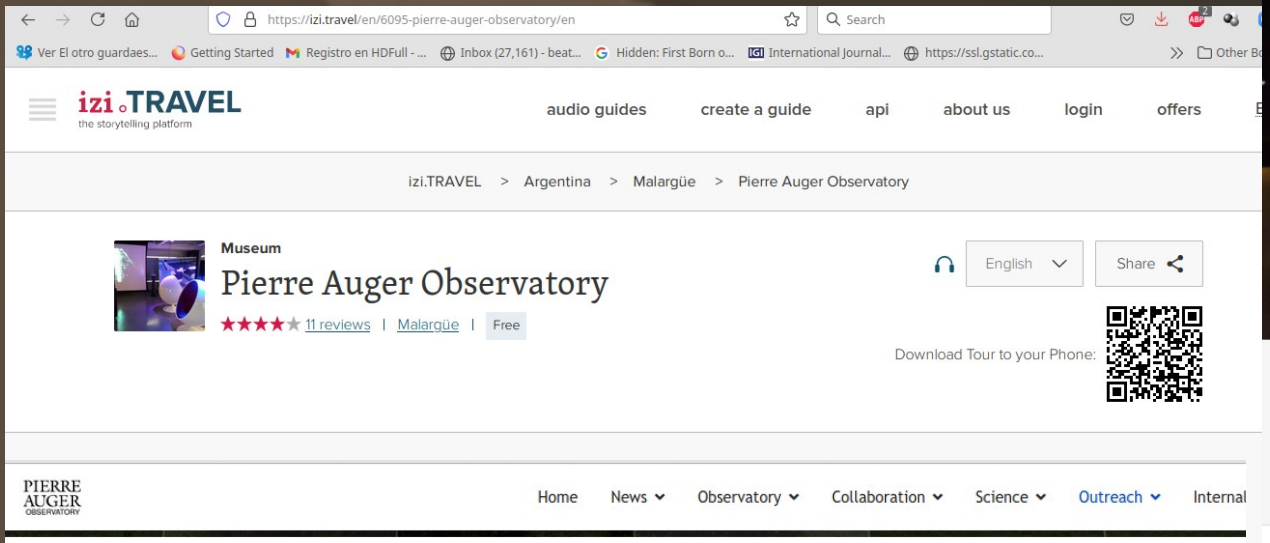
- **Why we are here?**
- **Which is the fundamental law that explains the Nature?**

Observation of the extreme universe can give us totally unexpected insights



COMPOSITE

Virtual Tours



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MOSTRAR RESEÑAS

Colecciones

Bienvenidos al Observatorio Pierre A...

24 objetos

Todos los objetos

24 objetos